Avian influenza, the wild bird trade and local livelihoods: an interdisciplinary and mixed-methods approach

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Abstract

Emerging infectious diseases (EID) are increasing in frequency with zoonoses originating in wildlife posing the greatest threat to global health. Highly pathogenic avian influenza (HPAI) strain H5N1 is the most expensive and widespread zoonotic disease to emerge recently. First detected in China in 1996, the virus subsequently spread across Asia, Europe, Africa and the Middle East resulting in tens of millions of animal deaths, primarily poultry as well as 329 fatal human cases. This thesis utilises a range of techniques from multiple disciplines to address questions relating to EID epidemiology and control through to the impacts of HPAI H5N1 at the household level within Vietnam. The methodologies employed include adapting an analytical framework to address a public health problem, semi-structured interviews within central Hanoian and rural Vietnamese households, structured questioning, direct surveys of the live bird markets and key-informant interviews.

This thesis has identified rapid growth in the trade and exploitation of birds for cultural and recreational human practices within Vietnam which involve several HPAI H5N1-susceptible species and promote ideal conditions for pathogen transmission. We estimate that three million birds annually are extracted from the wild to supply religious merit release practices in Vietnam alone. At the household level, poultry was found to be an important protein source for urban Vietnamese households and kept primarily for consumption by the majority of rural households. We found urban poultry consumers choose to take protective actions to limit direct exposure to HPAI H5N1whilst rural households choose to persist with the keeping of household poultry flocks despite the potential risks to household health and livelihood stability. We also identify substantial under-reporting of HPAI H5N1 outbreaks to global surveillance databases and consider the implications of this for HPAI H5N1 surveillance programmes. The thesis concludes by bringing together the different aspects of HPAI H5N1's impacts within Vietnam and emphasises the value of multidisciplinary approaches to studying the impacts of EIDs.

Chapter 1
General Introduction

Current threats of zoonotic diseases

The incidence of emerging infectious disease (EID) events has increased sharply since 1940, peaking in the 1980s, potentially as a consequence of the HIV/AIDS pandemic resulting in a growing population of people susceptible to pathogen infection (Jones *et al.* 2008). Since 1980, on average one new EID has appeared in humans every eight months (Karesh *et al.* 2005) with the emergence of these pathogenic infectious diseases representing a substantial global threat to human health (Binder *et al.* 1999; Daszak *et al.* 2000). A range of causal factors for the increase in EIDs have been identified and include more frequent and improved human global travel, increased human population density, translocation of animal species, changes in agricultural practices and poorly focused health monitoring (Binder *et al.* 1999; Daszak *et al.* 2000; Bell *et al.* 2004; Jones *et al.* 2008).

Global pandemics, such as HIV/AIDS and severe acute respiratory syndrome (SARS) coronavirus; the first pandemic of the 21st century (Bell *et al.* 2004), both had their origins in wildlife (Cunningham 2005). Recent research has identified that of all EIDs, 60.3% are zoonoses originating in wildlife and these represent the most significant growing threat to global health (Chomel *et al.* 2007; Swift *et al.* 2007; Jones *et al.* 2008). Examples of key recent EID outbreaks include Ebola haemorrhagic fever (Weiss 2001; Swift *et al.* 2007), SARS coronavirus (Bell *et al.* 2004) and highly pathogenic avian influenza (HPAI).

Highly pathogenic avian influenza strain H5N1

HPAI viruses have been widespread throughout parts of the globe since the early 20th century (e.g. Reid *et al.* 1999; Peiris *et al.*2009; FAO 2011). HPAI strain H5N1 was first detected in Asia in 1996 in a goose in Guangdong province in the People's Republic of China (Xu *et al.*1999). The virus was largely contained within China and Hong Kong until late 2003 when HPAI H5N1 experienced its first epizootic wave originating in Southeast Asia and consequently spreading across a vast geographical

area, spanning 3 continents (Olsen *et al.* 2006) and 61 countries; with human deaths reported in 12 of these countries. This panzootic is responsible for the deaths of tens of millions of animals through direct mortality and control programmes, primarily poultry taxa but also a range of other avian and mammalian species (see Appendix A).To date, 329 human deaths have occurred from 562 confirmed cases (58.5% mortality rate; WHO 2011). The countries of Southeast Asia have been hardest hit by HPAI H5N1 with 44.4% of human deaths occurring in Indonesia (146 of 178; WHO 2011) and over 50 million domestic poultry lost in Vietnam as a result of HPAI H5N1 (Sims & Dung 2009; FAO 2011; Figure 1).

The current HPAI H5N1 panzootic is the most extensive and expensive animal disease ever recorded (Zessin 2006; Dudley 2008) which is complicated by the enormous capacity for pathogenicity that H5N1 has been shown to have across a range of taxa. Fatalities due to HPAI H5N1 have been reported in 15 of the 27 avian orders as well as in mammalian families including felids, viverrids, mustelids and non-human primates (see Appendix A, Keawcharoen *et al.* 2005; Thanawongnuwech *et al.* 2005; Tiensin *et al.* 2005; Martin *et al.* 2006; Roberton *et al.* 2006; Gauthier-Clerc *et al.* 2007; Dudley 2008; USGS 2011). Some of the countries affected by HPAI H5N1 have successfully eliminated the virus whilst others have failed to eradicate the virus and now maintain an endemic status (FAO 2011). Due to the pan-global distribution of HPAI viruses, there are likely to be outbreaks which have gone undetected or unreported, particularly in remote, poorly educated, rural communities.

The spread of HPAI H5N1 from Southeast Asia into Europe and Africa emphasises the need to better understand the mechanisms of disease transmission (Kilpatrick *et al.* 2006; Guberti and Newman 2007). The poultry trade and the mechanical movement of infected materials are likely modes for spreading HPAI (Alexander 2000; Capua and Marangon 2006; Olsen *et al.* 2006; FAO 2011). The phenology and geographical pattern of expansion of the virus has been seen to contradict the patterns of bird migration (Gauthier-Clerc *et al.* 2007) which has fuelled the speculation as to the role of migratory wild birds in the geographical spread of the disease (Kilpatrick *et al.* 2006; Melville and Shortridge 2006; Olsen *et al.* 2006; Gauthier-Clerc *et al.* 2007; Guberti and Newman 2007; Pfeiffer 2007). Several hypotheses regarding the movement of

HPAI viruses have been proposed but recent research rejects the notion that migratory bird species are the key dispersal agent. Instead, live bird markets, poultry waste products, animal feed, religious bird releases and international trade in poultry and poultry products are all as likely means of transmission for the virus (Martin *et al.* 2006; Alexander 2007; Chomel *et al.* 2007; Gauthier-Clerc *et al.* 2007; Dudley 2008; Gilbert *et al.* 2008).

Between late-2003 and mid-2008, Vietnam experienced five epizootic waves of HPAI H5N1 virus followed by sporadic outbreaks to the present day, with outbreaks predominantly occurring in the Red River and Mekong River deltas (in the North and South respectively) (Soares Magalhães *et al.* 2010, FAO 2011, Figure 1). A possible trigger for the epizootic waves recorded across Vietnam, may be the onset of Tet (Vietnamese New Year) when the movement of poultry increases as poultry are brought into households and slaughtered during a traditional ceremony (Martin *et al.* 2006; Pfeiffer *et al.* 2007, Figure 1). The increased poultry production associated with this time of year was identified as correlating with Tet during the first and second epizootic waves in Vietnam (Fig. 1; WHO 2011). There is also evidence to suggest that the demographics and seasonality of the free-grazing duck production sector may also influence the temporal variability in HPAI H5N1 prevalence (Pfeiffer *et al.* 2007; Gilbert *et al.* 2008). The duck restocking cycle is planned so as to allow the young ducks to benefit from the rice-foraging peak of the monsoon-associated rice harvest from November-January (Gilbert *et al.* 2008).

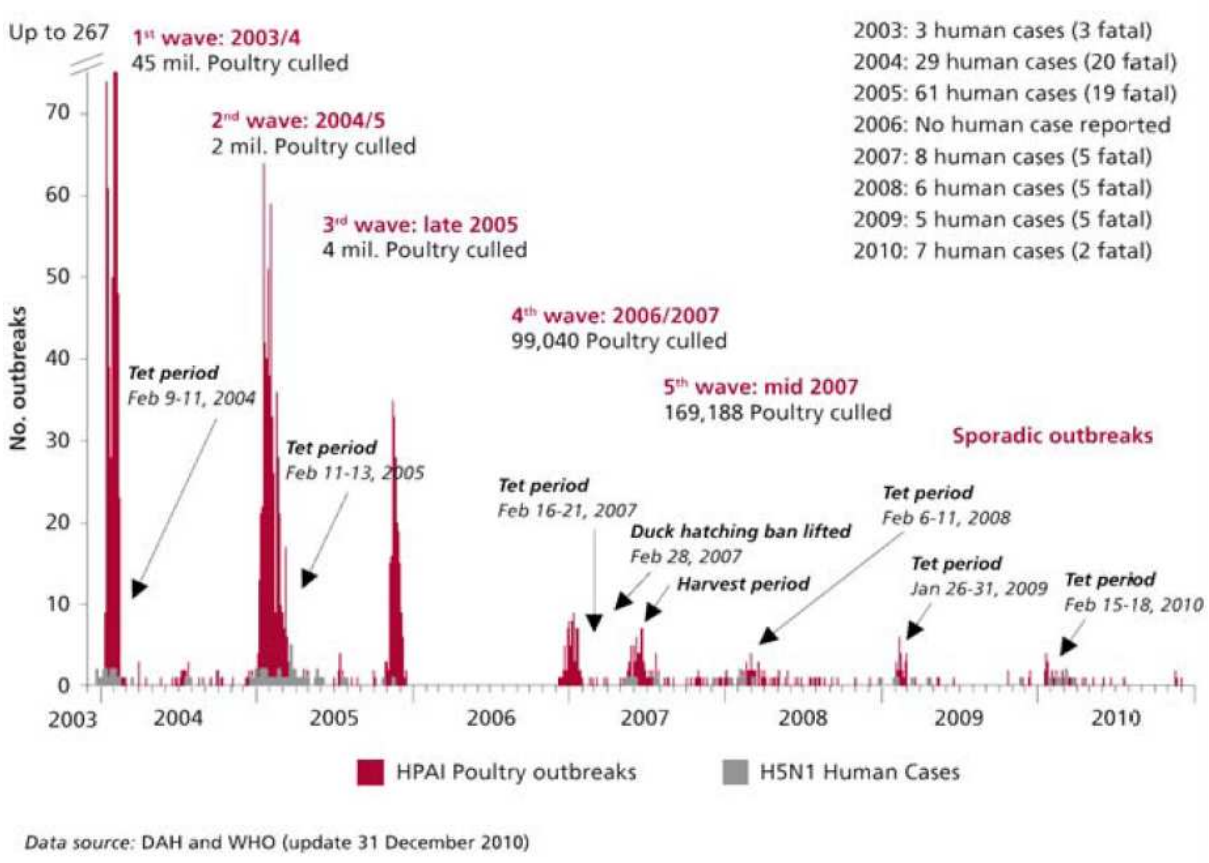

Figure 1 The number of human cases and poultry outbreaks of highly pathogenic avian influenza H5N1 strain in Vietnam from January 2004 through to December 2010, taken from FAO 2011. DAH-Department of Animal Health, Vietnam; WHO-World Health Organisation.

Whilst HPAI H5N1 is pathogenic in numerous bird species, knowledge of the epidemiology of the disease, particularly how it spreads between species and geographic localities, is lacking (Gauthier-Clerc *et al.* 2007). Numerous surveillance programmes have been set up such as the Wildlife Conservation Society's Global Avian Influenza Network Surveillance (GAINS), the United States of America surveillance system; Highly Pathogenic Avian Influenza Early Detection Data System (HEDDS) as well as wild bird surveillance by national governments and international organisations such as the Food and Agricultural Organisation of the UN (FAO). Despite the widespread effort given to HPAI H5N1 surveillance, to date only two studies have demonstrated apparently healthy wild waterfowl to be positive for HPAI H5N1 (Chen *et al.* 2005; Feare & Yasué 2006; Lvov *et al.* 2006).

Live bird trade and disease transmission

The current HPAI epidemic is directly related to infected birds sold live in traditional markets (Chomel *et al.* 2007). Research has shown that live bird markets may have been involved in fatal human infection with HPAI H5N1 and it was recommended that the sale of live birds directly to consumers should be discouraged in areas which are experiencing influenza outbreaks amongst birds, particularly in large modern cities (Mounts *et al.* 1999; Wang *et al.* 2006). The movement and trade in live birds is recognised as a risk factor in the transmission and spread of HPAI viruses between birds (Gilbert *et al.* 2008; Gilbert *et al.* 2011). The activities involved in the trade of live birds results in birds and humans from numerous localities mixing and congregating within one arena; ideal for the transmission of zoonotic pathogens such as HPAI viruses, giving rise to the potential for virus re-assortment (Kung *et al.* 2003; Nguyen *et al.* 2005).

Trade in live poultry

Vietnamese poultry consumers prefer fresh meat and therefore prefer birds to be slaughtered after purchase (Kung *et al.* 2003), a custom which exacerbates the risk of HPAI transmission from poultry to humans (Pfeiffer *et al.* 2007). Prior to HPAI outbreaks occurring in Vietnam, > 95% of total poultry output was sold as live birds (Hong Hanh *et al.* 2007). These birds were sold with no animal health certification, produced under questionable hygiene conditions and offered for sale at farm gates, in wet (live) markets, rural markets, along road sides as well as in temporary markets within cities (Hong Hanh *et al.* 2007).

Within areas of Southeast Asia (including Vietnam) and Africa, the number of H5N1-infectious bird days associated with the poultry trade has been estimated to be > 100-fold higher than for the wild bird trade and migratory birds (Kilpatrick *et al.* 2006). This figure is likely to be an over-estimate due to unreported trade happening within the illegal wildlife trade.

Trade in live ornamental birds

The global market for wildlife products provides ample opportunity for the widespread transmission of animal diseases (Daszak *et al.* 2000). This trade is frequently conducted

illegally and as such this poses a risk for disease control as animals are unlikely to be subject to the same veterinary controls and biosecurity measures as legally traded wildlife (Fèvre *et al.* 2006). These potential transmission mechanisms for zoonotic pathogens may not only result in human disease outbreaks, but also threaten livestock, international trade, rural livelihoods, native wildlife populations, and the health of ecosystems (Karesh *et al.* 2007).

It has long been acknowledged that wild birds play an important role in the transmission and perpetuation of low pathogenic avian influenza viruses (FAO 2011) but some debate exists over the potential role which they may play in the transmission of HPAI viruses. A recent study using satellite telemetry has shown that whilst migratory wildfowl can potentially transmit HPAI H5N1 over vast distances, each bird is estimated to only have 5-15 days each year when the virus could potentially be transported more than 500km (Gaidet *et al.* 2010). These findings, combined with knowledge of migratory patterns and behaviour, led to the conclusion that long-distance virus transmission would require a relay of successively infected birds who each acquire asymptomatic infection at consecutive migration stopover points (Gaidet *et al.* 2010).

An estimated four million live birds are transported around the globe annually (Karesh *et al.* 2005). These wild birds are traded through centres which commonly lack stringent biosecurity controls and thus, these birds may come into contact with dozens of other species before being shipped to other markets, sold locally or even released into the wild through religious customs such as merit release or as an unwanted pet (Karesh *et al.* 2007). Within Southeast Asia, the trade in wild birds is largely fuelled by demand for these birds for personal consumption, as a means of livelihood through trade, to release during religious ceremony as well as an ornamental attraction to be kept as pets (Karesh *et al.* 2007). Hunters, middle marketers and consumers all experience some form of contact with each animal passing through the trade and it is suggested that at least some multiple of one billion direct and indirect contacts among wildlife, humans and domestic animals result from the wildlife trade annually (Karesh *et al.* 2005). This figure, combined with the growing incidence of EID events and the capacity of viruses such as HPAI viruses to cross species boundaries, identifies the wildlife trade as a key driver in the transmission and spread of EIDs.

Within Vietnam, previous surveys of the live bird markets within Hanoi found that the keeping of caged birds had been increasing in popularity up to 2003 (Morris 2001; Franklin 2005). However, a 2007 study found this trend to have declined with fewer birds available for sale in the Hanoi's live ornamental bird markets compared to the earlier surveys (Brooks-Moizer *et al.* 2008). This decline was attributed to the enforcement of legislation introduced by the Vietnamese government in 2005 in an attempt to control the spread of HPAI and as such it includes a ban on the movement and sale of wild ornamental birds in urban areas (Brooks-Moizer *et al.* 2008). The extent to which this legislation continues to be enforced within Vietnam's urban bird markets is unknown.

Backyard poultry production in Vietnam

Global estimates predict that poultry will contribute approximately 40% of total animal protein by 2015 (IFPRI 2000). Poultry is of particular importance to poor rural communities due to the relative ease with which households can become involved in keeping poultry (Sonaiya 2007). Family poultry is one of the few livelihoods which poor, rural people can partake in even if they are lacking in resources such as land, capital and education (Branckaert and Guèye 2000; Sonaiya 2000). Outbreaks of HPAI H5N1 and the associated efforts to control these have resulted in the culling of entire family and village flocks within a risk perimeter of the infection site (Sonaiya 2007).

Traditional smallholder production dominates national poultry output in Vietnam (approximately 60% in 2006) (Burgos *et al.* 2007; Hong Hanh *et al.* 2007) but these traditional smallholdings are coming under direct and indirect threat from HPAI. Prior to HPAI outbreaks in Vietnam, government policy supported all farm types participating in poultry raising and as a consequence, bird populations rapidly increased across production systems (Hong Hanh *et al.* 2007). However, as a result of the persistent HPAI outbreaks, government policy attention is now more focused on semi-industrial commercial and industrial systems than on traditional household poultry raising (Hong Hanh *et al.* 2007). Several provinces in Vietnam, including the main cities and areas of high poultry production such as Hanoi and Ho Chi Minh City, have policies to promote semi-industrial and industrial poultry production (Burgos *et al.*

2007; Hong Hanh *et al.* 2007). Both central and local government provide farmers with preferential interest rates on loans, assistance in poultry breeding techniques, technical training in poultry raising and health and marketing services (Hong Hanh *et al.* 2007). These livestock development policy biases reinforce and strengthen the process of structural change currently happening within the poultry sector which is adding to the disadvantages of poor rural smallholders (Hong Hanh *et al.* 2007). One key aspect that has become clear as HPAI H5N1 continues to affect Vietnam, is the serious need for additional funding to be invested in veterinary services (FAO 2011), particularly on the ground to improve farmers' access to accurate advice and information and an all-round quality veterinary service.

In 2003, shortly before the first outbreaks of HPAI H5N1 in Vietnam, there were estimated to be 254 million poultry birds in the whole country. By 2005 the poultry population had declined to approximately 220 million, 15-16 percent less than the peak of 2003 (Hong Hanh *et al.* 2007). Within Vietnam, poultry production is a traditional occupation associated with rice cultivation (Hong Hanh *et al.* 2007). Poultry is a relatively small but important source of food and income for poor households in Vietnam (Epprecht *et al.* 2007). Family poultry contributes an estimated US$ 550 million, which is equivalent to 5%, of total Vietnam GDP with the majority of poultry producers coming from poor rural households (Otte *et al.* 2006).

With almost 80% of rural Vietnamese households participating in backyard poultry production (Hong Hanh *et al.* 2007), the keeping of household poultry provides many poor rural households with a year-round valuable source of protein as well as financial income (Otte *et al.* 2006; Thorson *et al.* 2006; Hong Hanh *et al.* 2007) whilst requiring relatively little land, investment and maintenance. Within Vietnam, poultry (predominantly chickens and ducks) are geographically concentrated near urban centres such as Hanoi in the North and Ho Chi Minh in the South. The Red River and Mekong River deltas are both major poultry producing areas (Burgos *et al.* 2007; Hong Hanh *et al.* 2007) with chickens outnumbering ducks and geese in the Red River delta and the converse being the case in the Mekong River delta (FAO 2007; Hong Hanh *et al.* 2007).

Indirect impacts of HPAI H5N1 outbreaks

Disturbances to poultry production systems, such as outbreaks of HPAI, will have wide ranging impacts with the greatest effect felt by poor rural communities. The current HPAI H5N1 epidemic is not only a public health problem (Kilpatrick *et al.* 2006) but also an economic and food security impact for many of the Vietnamese who live in rural areas (Thorson *et al.* 2006). Measures to control outbreaks of HPAI H5N1 has resulted in the culling of millions of domestic poultry (OIE 2008), over 50 million in Vietnam alone (Sims & Dung 2009). These disease control measures, whilst essential in controlling the spread of the virus, are depriving households of valuable protein in their diet, cash income and perhaps most importantly, an investment opportunity for escaping poverty (Epprecht *et al.* 2007).

The direct impacts of H5N1 on human health has somewhat overshadowed indirect impacts such as the loss of family poultry which are valuable resources to the majority of rural families within Vietnam. As a result, the effects of HPAI outbreaks on rural communities and local economies have received little research attention and financial investment relative to the direct impacts of HPAI H5N1 on human health.

Impact of HPAI H5N1 on local livelihoods

Participating in backyard poultry production is a risky business due to unpredictable markets and economies, unstable weather events and the risks of disease outbreaks (Eklan 2001; Oparinde & Birol 2008). For rural poultry-keepers, disease outbreaks in their poultry flocks may have negative consequences for household food security, income and livelihood stability. Households experiencing livelihood stress may seek to diversify their livelihood in an attempt to regain stability (Ellis 2000) or to employ a range of strategies in an attempt to regain food security (Sonaiya 2000). Livelihoods and food systems under stress can result in households taking unusual and risky actions, such as the consumption of birds suspected to have died of HPAI H5N1 (Sonaiya 2000; Sonaiya 2007) in an attempt to minimise the disruption to their livelihood. Maintaining a livelihood which can withstand the shocks and stresses (widely known as sustainable livelihoods see e.g. Ellis 2000) is essential for ensuring future household livelihood security and stability (Devereux 2001).

The incidence of zoonotic disease emergence is on the increase and a growing proportion of rural-poor are dependent on livestock as a means of livelihood stability. Knowledge regarding the contribution of human activities to the transmission and spread of such emerging and re-emerging potential pandemic pathogens is vital for improving public health and pandemic preparedness. Developing this knowledge alongside an understanding of the impacts which these disease outbreaks will have on human populations is central to maintaining and improving global public health programmes, food security and livelihood security for vulnerable communities, and ensuring healthy wildlife populations. Undertaking holistic research aimed at developing our understanding of how such interdisciplinary topics link together is imperative for ensuring the health of both people and biodiversity.

Thesis structure

This interdisciplinary thesis comprises of one chapter which introduces an analytical framework followed by five chapters based on a range of empirical data, collected using a variety of methodological approaches to address questions related to the impacts of highly pathogenic avian influenza H5N1. All chapters follow a manuscript format; one of which (chapter 3) has been accepted for publication.

Chapter 2 presents an analytical framework commonly utilised in food production and food safety systems. Using Vietnam's poultry trade chain and outbreaks of HPAI strain H5N1 as a case study, it discusses the potential for using this framework when tackling emerging infectious disease outbreaks.

Chapter 3 is the first of the chapters based on empirical data. A combination of direct surveys of the birds available for sale in wild bird markets and shops across Vietnam and interviews with live bird vendors are used to determine the risk that this trade poses for the transmission of pathogens, particularly HPAI H5N1.

Chapter 4 builds upon the links explored in chapter 2 regarding the exploitation of birds and pathogen transmission. Here we consider the potential for traditional practices involving the exploitation of birds to provide a means for pathogen transmission. Three

key traditional practices in both Vietnam and Thailand are investigated and comparisons made between the practices across these two Southeast Asian countries.

Chapter 5 explores the role of poultry within the households of rural backyard poultry farmers in two areas of Vietnam. It gives particular focus to the persistence of rural poultry farmers to pursue life as a poultry farmer during a turbulent time for poultry production with the constant threat of disruptive disease outbreaks such as HPAI H5N1. Two hundred and eighteen semi-structured interviews were conducted across ten communes within two provinces; Quang Ninh in northeastern Vietnam on the Vietnam-China border and Quang Nam in central Vietnam situated on the Lao PDR-Vietnam border with the South China Sea to the east.

Chapter 6 utilises the data from semi-structured interviews carried out in Quang Ninh and Quang Nam provinces and addresses questions regarding the reporting of HPAI H5N1 outbreaks, the use of preventative measures to protect poultry flocks and the awareness and knowledge which backyard poultry farmers have regarding HPAI H5N1 in their communities. Using data taken from the database of the World Organisation for Animal Health and data acquired in Vietnam, discrepancies in the reporting of HPAI H5N1 outbreaks at local and international levels are also revealed.

The final data chapter, *chapter 7* is based on the data from a survey of 406 households within central Hanoi. These data are used to determine the role of poultry within urban households as well as the knowledge and awareness which Hanoians have regarding HPAI H5N1 and the preventative measures taken to protect members of their households from such viruses.

Finally, the findings from the individual data chapters are synthesised in *chapter 8* where we also discuss the interdisciplinary nature of this thesis as well as suggesting future directions arising from this research.

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Chapter 2

Hazard Analysis of Critical Control Points Assessment as a Tool to Respond to Emerging Infectious Disease Outbreaks

Plucking slaughtered poultry on a Hanoi street. Photo by Kelly Edmunds.

ABSTRACT

Highly pathogenic avian influenza virus (HPAI) strain H5N1 has had direct and indirect economic impacts arising from direct mortality and control programmes across at least 61 countries reporting outbreaks. Across Vietnam alone, over 50 million domestic poultry have been lost in what is now reported as the most widespread and expensive animal disease recorded.

Using the Hazard Analysis of Critical Control Points (HACCP) technique, we assess Vietnam's poultry trade as a contributor to the transmission of HPAI viruses. This novel approach applies a process widely used in food production systems (and increasingly in public health systems) to assess risks related to a specific emerging health threat, closely linked to food production within a known zoonotic disease hotspot.

We compare the findings of our HACCP assessment with those of the existing literature and discuss the role that HACCP assessments may play as an early response to emerging infectious disease outbreaks.

INTRODUCTION

Since late 2003, highly pathogenic avian influenza virus (HPAI) strain H5N1 has been responsible for the deaths of millions of animals, primarily poultry taxa but also a range of other avian and mammalian species (WHO 2010a). HPAI H5N1 has been reported in species from at least 61 countries with 329 human deaths among 562 confirmed cases (58.5% mortality rate) recorded in 12 of these countries (WHO 2010b). The countries of Southeast Asia have been hardest hit by HPAI H5N1 with 44% of human deaths occurring in Indonesia (146 of 329; (WHO 2011)) and over 50 million domestic poultry lost in Vietnam as a result of H5N1 (Sims & Dung 2009). The current HPAI H5N1 panzootic is the most extensive and expensive animal disease ever recorded (Zessin 2006; Dudley 2008)

HPAI viruses have been established in Vietnam's poultry population since 2003 (Henning *et al*. 2009). Shortly before the first outbreaks of HPAI in Vietnam, it was estimated that there were 254 million poultry birds across the whole country. By 2005 this had declined to approximately 220 million, 15-16% less than 2003 (Hong Hanh *et al.* 2007). Approximately 80% of the Vietnamese population live in rural areas (Thorson *et al.* 2006) and almost 80% of these rural Vietnamese households participate in small-scale (backyard) poultry production. It has been suggested that participating in domestic duck raising in Vietnam can increase the likelihood of HPAI H5N1 infection by up to eight times (Webster & Hulse 2005).

The Red River and Mekong River deltas (in the North and South respectively) are major poultry producing areas (Hong Hanh *et al.* 2007; Burgos *et al.* 2007) with chickens outnumbering ducks and geese in the Red River delta and the converse in the Mekong River delta (Hong Hanh *et al.* 2007; FAO 2007). From these key areas, poultry and their products (e.g. eggs, dung, feathers) may be transported directly to the point of sale by the breeder or pass through a number of middlemen in the trade chain. Live and dead birds as well as poultry products may travel between households, villages, markets and provinces as they move towards the point of consumption. Despite a national poultry vaccination campaign across Vietnam in 2005 and an ongoing widespread vaccination programme, HPAI H5N1 continues to affect poultry and households across the country

with 43 poultry outbreaks and seven human cases in 2010 (to 07/12/2010, (WHO 2010a)).

HPAI H5N1 spread rapidly from Southeast Asia into Europe and Africa (Kilpatrick *et al.* 2006; Guberti & Newman 2007). It is already known that the main mechanism for HPAI spread is the movement of poultry and their products (Eagles *et al.* 2009; Webster *et al*. 2006). In addition, live poultry markets are acknowledged as both a reservoir for the virus and for their role in viral perpetuation within the Southeast Asia region (Webster *et al*. 2006; Kung *et al.* 2003).

We have taken a technique more commonly utilised within food production and to a lesser extent, public health systems, and applied this to HPAI viruses within a poultry trade system. When Hazard Analysis of Critical Control Points (HACCP) assessments are applied to food production systems, seven principles are recognised as aiding in the identification, evaluation and control of hazards, pertaining to a particular system (Krumkamp *et al.* 2009). HACCP techniques are increasingly being employed to identify risks within the public health arena where only the first three of the seven standard HACCP principles apply (MacLehose *et al.* 2003). We explore the role that HACCP analyses may have in catalysing efforts to tackle emerging infectious diseases outbreaks through conducting a HACCP assessment for Vietnam's domestic poultry trade. We identify the key stages within this poultry trade chain which pose risks for i) the perpetuation of HPAI viruses within the domestic environment and ii) the transmission of HPAI viruses in human and poultry populations. We then discuss the potential use of HACCP assessments as a rapid response tool during the early stages of emerging infectious disease outbreaks, as a precursor to the more time consuming quantitative data collection and biomedical testing.

METHODS

The HACCP assessment of Vietnam's domestic poultry trade followed the key principles attributed to HACCP analyses (see e.g. (Motarjemi *et al.* 1996; Hulebak & Schlosser 2002)). We used the first three HACCP principles (described in Table 1) to address our aims.

Table 1 The first three principles of a Hazard Analysis of Critical Control Points assessment, as typically employed during analyses within public health systems

	Aims	Actions
Principle 1	Outline key 'risk' stages in system under investigation.	Conduct hazard analysis. Create flowchart of stages involved within the system in question and validate the flowchart through liaison with experts.
Principle 2	Identify Critical Control Points (CCPs) within the system	Critical review of the system to highlight stages which can adopt mitigation strategies for hazards known to occur frequently
Principle 3	Develop CCPs and control recommendations for the recognised hazards	Ascertain critical limits for the CCPs identified and use these to generate recommendations for the improvement of the overall system.

The initial flowchart created during the first stage of HACCP principle 1 (Appendix B) was developed based on knowledge of Vietnam's poultry trade following eight months of research within Vietnam. The flowchart begins with a poultry egg and tracks all the possible routes that this egg could take through Vietnam's domestic poultry trade. This flowchart was then presented to a range of experts for critical analysis; including public health professionals, epidemiologists and wildlife disease biologists. A hazard was considered to be a process within Vietnam's domestic live poultry trade providing an opportunity, at an unacceptable level of risk, for the transmission of HPAI either from poultry to human or poultry to poultry. Taking into account the frequency with which these hazards occur, they were then grouped into categories based on whether they pose a high or low risk to poultry and/or humans.

Following the validation of the flowchart, we again referred to the team of experts to determine appropriate Critical Control Points (CCPs). A CCP is a point in Vietnam's domestic poultry trade which provides an opportunity to control, prevent or eliminate the risks for HPAI transmission within this live poultry trade system.

Each of these first two principles required cross-referencing the outputs with existing literature on HPAI viruses; their transmission, epidemiology, presence within Vietnam's poultry trade as well as the structure of this trade.

Critical limits were then set for each of the CCPs identified. These critical limits are thresholds used as preventative measures at each of the CCPs to control the hazards within the system. Setting the critical limits required prior knowledge, obtained through eight months spent in Vietnam, of both Vietnam's domestic poultry trade and consumer behaviour so as to ensure that the critical limits are both practical and reasonable.

RESULTS

Hazard Analysis

The HACCP assessment focused on identifying stages of Vietnam's domestic poultry trade which pose the greatest risks for transmission of HPAI viruses between poultry individuals and also from poultry to humans. Table 2 shows the stages of the poultry trade chain which have been identified as presenting increased opportunities for HPAI transmission.

The increased risk activities highlighted by our HACCP (Table 2) can be loosely grouped into three categories: 1. mixing of flocks, 2. poultry transportation and sale, and 3. poultry preparation and consumption.

Table 2 Stages within Vietnam's poultry trade which Hazard Analysis of Critical Control Points assessments have identified as presenting increased opportunity for highly pathogenic avian influenza virus transmission

	High Risk	Low Risk
Poultry – Poultry Transmission	Flock mixing at markets Slaughter of birds Participation in fighting cock events Transportation of live birds	Communal poultry vaccinations Free-ranging of village poultry flocks
Poultry – Human Transmission	Consumption of under-cooked meat and eggs Slaughter of birds Incorrect disposal of dead birds	Transporting fighting cocks post-bout Transportation of live birds

1. Mixing of flocks

The mixing of poultry flocks occurs at multiple stages and localities within the poultry trade. These potential viral 'mixing pots' exist when i) established flocks mix with newly recruited birds bought by the farmer; ii) flocks mix whilst awaiting sale at a market; iii) flocks mix whilst awaiting transport back to the household following their purchase at a market; iv) birds mix at communal HPAI H5N1 vaccinations centres and v) fighting cock contests bring birds together in one close-contact arena. Each of these five scenarios present high risk opportunities for poultry to poultry transmission whereas scenarios i), iv) and v) also present high risk opportunities for poultry to human transmission.

2. Poultry transportation and sale

Poultry may experience multiple transportation and sale events across a large spatial scale throughout an individual's lifetime. At all stages of the poultry trade, the transportation and sale of eggs, chicks, adult birds or poultry products, creates opportunities for human-mediated transmission of HPAI viruses. Due to the close contact and considerable number of poultry involved in transportation across these large spatial scales, the transportation and sale of poultry is considered a high risk activity for HPAI transmission from both poultry to poultry as well as poultry to humans.

3. Poultry preparation and consumption

The preparation of poultry for consumption introduces poultry to human HPAI transmission risks into the latter stages of the trade chain, primarily through the slaughtering procedure. In the absence of appropriate hygiene practices, poultry slaughtering and carcass preparation put the slaughterer at substantial risk of exposure to HPAI viruses due to the close and prolonged contact with raw and bloody poultry. People involved in the repeated slaughtering of poultry will have an exposure risk which increases accordingly.

Poultry consumption (including the consumption of meat, eggs, organs and blood from both chickens and ducks) is a high risk activity for HPAI transmission from poultry to humans due to the consumption of under-cooked meat, eggs or organs and raw blood pudding. Contrastingly, the consumption of well-cooked poultry and poultry products pose low risks for poultry to human transmission of HPAI viruses.

Critical Control Points and Critical Limits

CCPs were defined for each of the three risk stages identified during the HACCP assessment of Vietnam's poultry trade. Each CCP is a point within the live poultry trade which provides HPAI viruses with an opportunity to move between host animals, increasing the potential for virus transmission. For each CCP, critical limits have been proposed and these should be employed to limit virus transmission risks (Table 3).

Table 3 Risk stages, critical control points and proposed critical limits identified through Hazard Analysis of Critical Control Points assessments for highly pathogenic avian influenza virus transmission via Vietnam's poultry trade

Risk Stage	Critical Control Point	Critical Limits
1.Flock mixing		
i)Newly recruited birds introduced into established flocks	Introduction of 'foreign' birds to an established flock	Flock vaccination Flock isolation, quarantine newly-purchased birds,
ii)Awaiting sale at market	Arrival at market	Flock isolation, quarantine
iii)Awaiting transport back to household	Arrival/preparation for departure	Flock isolation, quarantine
iv)Communal poultry vaccination centres	Throughout vaccination	Flock isolation, quarantine
v)Fighting cock contests	Throughout contest	Isolation of birds, quarantine
2.Poultry transportation & sale		
Transportation of live birds	Transfer from household	Flock isolation throughout
Transportation of fighting cocks post-bout	Transfer post-fight	Isolation
3.Poultry preparation & consumption		
Consumption of under-cooked meat and eggs	Cooking	Cook thoroughly
Incorrect disposal of dead birds	Carcass disposal	Use protective equipment, follow protocols, avoid direct contact
Slaughter of birds	Poultry slaughter Collection of blood	
Free-roaming village poultry flocks	Release of flock	Flock isolation, quarantine

1. Mixing of flocks and 2. Poultry transportation and sale

The CCPs for limiting transmission through the mixing of flocks involve the same approach as those for the transportation and sale of poultry; a combination of flock isolation, quarantining newly purchased birds and household vaccination strategies (Table 3).

It is imperative that household flocks are isolated from each other throughout the trade to minimise the risks of inter-flock transmission occurring outside the flock's host household. CCPs for the transportation and sale of the poultry begin with the isolation of poultry flocks when they depart from their household of origin. The critical limit for this particular transmission risk is a total ban on inter-flock mixing of birds throughout all stages of poultry transportation and sale.

3. Poultry preparation and consumption

Preparing poultry for human consumption is the first stage of the trade chain when non-farmers are introduced to a high risk opportunity to contract HPAI viruses. Two key CCPs concern poultry preparation; poultry slaughtering and carcass preparation. The risks associated with these activities can be reduced through the correct use of protective equipment such as face masks, gloves and sterile utensils to prevent contact with raw and bloody poultry. These CCPs and their critical limits apply to both within household poultry preparation and the larger scale market-based poultry preparation.

Poultry consumption is not a substantial risk for poultry to human HPAI transmission provided poultry/poultry products are well cooked. With this in mind, the CCP for poultry consumption is the cooking stage with a critical limit of ensuring that only well-cooked poultry items are consumed. In the case of blood pudding, this must be well-cooked prior to consumption or not consumed at all. The consumption of raw blood pudding poses some of the highest risks for poultry to human transmission of HPAI viruses and controlling this risk is only possible through thorough cooking practices or abstaining from consumption altogether.

DISCUSSION

Our HACCP assessment has identified poultry flock isolation as well as the transportation, slaughter, preparation and consumption of poultry as critical control points for Vietnam's domestic poultry trade. Critical limits at each of these control points are recommended for implementation within Vietnam's poultry trade to control the risks of HPAI transmission from poultry to poultry and from poultry to humans. The hazards and control points identified affect all sectors of society but at different magnitudes within rural and urban Vietnamese households.

Poultry trade in Vietnam

The scope of Vietnam's poultry trade is far-reaching both geographically and across social classes. Rural Vietnamese households typically keep a few backyard poultry and are likely to consume these birds or birds from the flocks kept by their neighbours. In urban Vietnamese households, it is less common for poultry to be kept within the household and poultry for consumption are typically purchased at local markets (see

Chapter 7). If the HPAI H5N1 infection levels in poultry can be reduced then the threat of infection to humans is also reduced (Webster & Hulse 2005). Typically, the live poultry trade is dominated by birds sold with no animal health certification which had been produced under questionable hygiene conditions (Hong Hanh *et al.* 2007).

Poultry provides an important source of income as well as a low-cost protein source for many rural village Vietnamese households (Hong Hanh *et al.* 2007). Disturbances to poultry production systems, such as outbreaks of HPAI H5N1, have wide-ranging impacts throughout the poultry production and consumption chain with the greatest effect on poor rural communities. The current HPAI H5N1 epidemic is both a public health problem (Kilpatrick *et al.* 2006) and an economic problem for the many Vietnamese people living in rural areas (Thorson *et al.* 2006). The implementation of disease control measures following HPAI H5N1 outbreaks has resulted in the culling of millions of domestic poultry (WHO 2010a). Whilst these measures are essential in controlling the spread of the virus, they also deprive households of valuable protein, cash income and, importantly, an investment opportunity for escaping poverty (Epprecht *et al.* 2007).

Hazard Analysis

If the management of infectious zoonotic diseases is to be successfully implemented, controlling the transmission chain from infected to uninfected animals is essential (Eagles *et al.* 2009). Avian influenza virus transmission between birds may arise through direct contact or transportation alongside infected flocks, poultry products or contaminated and infectious materials (Capua & Marangon 2006). Our HACCP evaluation identified three categories of hazardous activities for HPAI transmission, 1. poultry flock mixing; 2. the transportation and sale of poultry; 3. poultry preparation and consumption. The successful implementation of critical limits and preventative measures recommended through this HACCP process is likely to depend upon factors specific to each hazard category.

1. Mixing of flocks

Due to the free-ranging nature of many rural poultry flocks, individual birds roaming within the same locality may have different exposure rates to HPAI viruses. Pathogens

may spread to birds from other flocks when the flocks mix and birds are moved (Savill *et al.* 2006) in a setting such as live markets, communal vaccination centres or during transportation. Ensuring the isolation of flocks throughout all stages of the poultry chain reduces the opportunities for inter-flock transmission. The stages of the poultry trade chain during which inter-flock transmission is most likely to occur are when i) newly recruited birds bought by the farmer are introduced into established backyard/farm flocks; ii) flocks mix whilst awaiting sale at a market; iii) flocks mix whilst awaiting transport back to a household following purchase at a market; iv) birds mix at communal HPAI H5N1 vaccinations centres and v) fighting cock contests bring birds together in one close-contact arena.

Incubation periods differ between chickens and ducks with reports of deaths occurring within 1-5 days for chickens and up to 7 days for ducks (Tian *et al.* 2005). As a result, at all stages, flocks of birds which have had the opportunity to mix with other poultry flocks should undergo a week-long quarantine period; after this time period asymptomatic birds can be released from quarantine. It has been noted that transmission of HPAI H5N1 between poultry appears to have shifted from the faecal/oral route towards the respiratory route (Eagles *et al.* 2009) which underlines the risks of mixing poultry flocks.

2. Poultry transportation and sale

Poultry and its products are often transported in considerable numbers across large spatial scales. During transportation, HPAI material may be shed by infected individuals and lead to other poultry coming into contact with viral material. The mixing and movement of poultry through ‘wet’ markets (those selling live animals) is known to play an important role in the transmission and spread of HPAI viruses (Bridges *et al.* 2002; Kung *et al.* 2002) and it has been reported that exposure to live poultry at wet markets increases human HPAI H5N1 exposure risk four-fold (Mounts *et al.* 1999).

Within some wet bird markets, the current control programme for HPAI viruses concentrates on the incorporation of rest days whereby the markets are shut down for trade purposes and poultry stalls are cleaned (VanKerkhove 2009). This has been particularly successful in Hong Kong which has a seen a reduction in the transmission

of HPAI and other avian viruses, attributed to the implementation of rest days (Kung *et al.* 2003). Such a practice has yet to be employed across Vietnam's cities and this practice is recommended, both to improve wet poultry market hygiene and reduce these market-based HPAI transmission risks.

3. Poultry preparation and consumption

The H5N1 virus strain is known to be able to survive in poultry carcasses kept at room temperature for several days and even longer at cooler temperatures (WHO 2007). Human infection with the H5N1 virus is associated with recent exposure to live poultry (Mounts *et al.* 1999) direct contact with dead poultry (Areechokchai *et al.* 2006) and the preparation or cooking of unhealthy, sick or dead poultry (Beigel *et al.* 2005; Dinh *et al.* 2006). As a result, poultry market workers and poultry slaughterers experiencing prolonged contact with poultry undergoing culling are at particular risk of human HPAI H5N1 infection (Bridges *et al.* 2002).

Within Vietnamese households it is typical to consume the meat, eggs and organs of both chickens and ducks. The consumption of chicken and chicken products varies from that of ducks with regard to parts consumed. Uncooked duck blood is commonly consumed for special occasions; a practice that has been implicated in poultry to human HPAI transmission (Beigel *et al.* 2005). It is also common to consume fertilised duck embryos and in many parts of Vietnam, these are considered a delicacy.

Additional risks

All poultry kept for sale purposes will experience at least one of the transmission risks posed through mixing poultry flocks. Exposure to hazards iv) and v) will depend on the vaccination system employed and the suitability of the birds for cock-fighting. In some communes the Department of Animal Health (DAH) organise door-to-door vaccinations where local veterinarians visit individual houses to vaccinate poultry flocks. In more remote villages, the DAH organise communal vaccination days where households from villages across the commune, bring their poultry to one centralised location for vaccination. This latter vaccination system encourages the mixing of poultry flocks from different localities and given the lag period before the HPAI H5N1 vaccine becomes effective, presents a high risk for the transmission of HPAI viruses within the

immediate area. Door-to-door vaccinations ensure a lower risk of inter-flock viral transmission and should be employed. Should this approach prove impractical, the isolation of flocks whilst at the communal vaccination centre must be ensured to limit the chances of inter-flock viral transmission. It is also noted that vaccination programmes are currently lacking any system of coordinated monitoring (Eagles *et al.* 2009) and introducing such a system will be vital in controlling virus spread.

Fighting cock contests may play a role in the transmission of HPAI viruses to humans (Webster *et al.* 2006; Beigel *et al.* 2005). Fighting cocks, particularly those with a record of winning bouts, are valued possessions bringing prestige for their owners. These owners transport their birds large distances to participate in bouts and even lick the wounds sustained by their fighting cocks (Liao *et al.* 2009). This practice likely aids the geographic spread of HPAI viruses (Webster *et al.* 2006) and is a risky activity for poultry to human HPAI transmission.

CONCLUSION

Birds raised and sold under conditions with limited veterinary controls and poor bio-security are likely to act as living vectors for pathogens such as HPAI viruses (Liao *et al.* 2009). Controlling intra-flock virus transmission in situations where birds live in high density flocks and where free-grazing of flocks is the norm is a continuing problem. Additional factors such as a lack of veterinary resources and the pressure on commune-level veterinary resources combine to exacerbate the problems of controlling the spread of highly contagious pathogens such as HPAI.

Introducing the preventative measures highlighted by this HACCP evaluation should reduce the occurrence of HPAI outbreaks and in turn, relieve pressure on the local veterinary departments and the local and national economies.

The parallel findings of our rapid HACCP assessment with the scientific literature cited, provide strong evidence for the potential that HACCP analyses have in the early stages of responding to emerging health threats. Whereas in-depth epidemiological studies can take weeks or months to produce results and recommendations, a HACCP analysis may

provide a means of producing evidence-based recommendations within days of an outbreak occurring.

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Chapter 3

Investigating Vietnam's ornamental bird trade: implications for transmission of zoonoses

Oriental Magpie Robin on display in a Hong Kong bird market. Photo by Kelly Edmunds

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ABSTRACT

Global wildlife trade is financially lucrative, frequently illegal and increases the risk for zoonotic disease transmission. This paper presents the first interdisciplinary study of Vietnam's illegal wild bird trade focussing on those aspects which may contribute to the transmission of diseases such as Highly Pathogenic Avian Influenza (HPAI) H5N1. Comparing January 2009 data with that of May 2007, we found a five-fold increase to 9117 birds on sale in Hanoi.

Ninety-five percent of Hanoian bird vendors appear unaware of trade regulations and across Vietnam vendors buy birds sourced outside of their province. Approximately 25% of the species common to Vietnam's bird trade are known to be HPAI H5N1 susceptible. The anthropogenic movement of birds within the trade chain and the range of HPAI-susceptible species, often traded alongside poultry, increase the risk Vietnam's bird trade presents for the transmission of pathogens such as HPAI H5N1.

These results will assist in the control and monitoring of emerging zoonotic diseases and conservation of Southeast Asia's avifauna.

INTRODUCTION

The international trade in wildlife products provides ample opportunity for the intercontinental transmission of wildlife diseases (Daszak *et al*., 2000). Illegal wildlife trade poses higher risks for disease control as animals are unlikely to be subject to the same veterinary controls as legally traded wildlife (Fèvre *et al*., 2006).

Over recent years, countries throughout Southeast Asia have been significantly affected by recurrent outbreaks of (Highly Pathogenic Avian Influenza) HPAI H5N1 virus (Olsen *et al*., 2006; Thorson *et al.*, 2006). Vietnam has reported more HPAI H5N1 poultry outbreaks than any other country, reportedly losing over 50 million domestic poultry as a direct result of HPAI H5N1 infection and control (Sims and Dung, 2009). In Vietnam, birds are some of the most popularly traded species with Hanoians identifying wild birds as being the most common live wild animal purchased (Drury, 2009). HPAI H5N1 transmission risk factors include exposure at live bird markets (Mounts *et al.* 1999; Wang *et al*., 2006); close interactions with poultry and the preparation of poultry for consumption (Bridges *et al*., 2002; Dinh *et al*., 2006). At least one fatal human infection with H5N1 has been linked to live bird markets leading to the banning of the sale of wild birds in H5N1 hotspots (Wang *et al.*, 2006).

When wild birds are traded, they are in contact with many other species before being shipped to markets, sold locally or released into the wild through religious practices (Karesh *et al*., 2005). Hunters, wholesale traders and consumers all experience some form of contact with each animal passing through the trade system. These factors, combined with the growing incidence of emerging infectious disease (EID) events and the capacity of viruses such as HPAI viruses to cross species boundaries, identifies the wildlife trade as a key driver in the transmission and spread of EIDs.

In the early 1990s, birds from Vietnam were reported in increasing numbers across Southeast Asia's markets (Nash, 1994). More recent surveys of live bird markets within Vietnam's capital of Hanoi indicated that the caged bird trade had been escalating up to 2003 (Morris, 2001; Franklin, 2005). However, a 2007 study found a decline in the number of birds on sale and this was attributed to legislation introduced by the Vietnamese government in 2005 (Decree 69/2005/TT-BNN; Brooks-Moizer *et al.*,

2008). This legislation, issued by the central Vietnamese government, details the restrictions put in place to limit the spread of HPAI H5N1 and includes a total ban on the transportation and sale of wild birds and ornamental birds across all of Vietnam's urban areas. Despite this ban, the trade in ornamental birds still occurs openly across Vietnam's cities.

This paper investigates the scale of the ornamental bird trade within Vietnam with particular focus on the characteristics of the trade which may contribute to the transmission of diseases such as HPAI H5N1. We report on the current extent of Hanoi's wild bird trade, the species being exploited and their IUCN (International Union for Conservation of Nature) threatened status. We describe the first surveys of ornamental bird shops in Hue and Da Nang cities and in Tinh Gia (Thanh Hoa province), as well as surveys in Hanoi and Ho Chi Minh City (HCMC) and compare the trade across these locations. Vendors were interviewed to determine the reasons that certain taxa are selected for purchase, their awareness of regulations concerning the trade in ornamental birds and the origins of the birds they sell. The potential role that these illegal markets may play in the spread of EIDs such as HPAI H5N1 is discussed.

METHODS

Market surveys – Hanoi

For the purposes of this paper, we refer to an ornamental bird market (OBM) as an area in which vendors sell wild birds from permanent shops. Several such markets had been identified during previous surveys (Morris 2001; Franklin 2005; Brooks-Moizer *et al.* 2008) and these were visited in October 2008 to determine whether OBMs were still operating.

From November 2008 to February 2009 monthly surveys were conducted in all known OBMs across Hanoi. During these surveys, one or two experienced surveyors counted the number of individuals of each bird species in every shop within each market. Due to the illegal nature of the trade, this information was recorded into a concealed dictaphone. All taxa were identified to species-level where possible with the exception of the three Munia species. (White-rumped Munia *Lonchura striata,* Scaly-breasted Munia *L. punctulata* and Chestnut Munia *L. atricapilla*), two Bushlarks (Indochinese

Bushlark *Mirafra erythrocephala* and Australasian Bushlark *M. javanica*) and two White-eye species (Oriental White-eye *Zosterops. palpebrosus* and Japanese White-eye *Z. japonicus*) which were grouped as Munia spp., Bushlark spp. and White-eye spp. respectively. The Munias were typically seen in mixed-species cages of up to 300 birds/cage making species-level counts very difficult, whilst the White-eye species are difficult to identify to species-level during such surveys. Any unknown species were described into the dictaphone and where possible, photos were taken to facilitate identification through the use of bird identification guides (Robson, 2005; Nguyen *et al.,* 2005) and consultation with local ornithologists. The larger markets have particular days, related to the lunar calendar, which are believed to be lucky for the purchase of special items such as ornamental birds and trees. Whenever possible the surveys took place on consecutive days each month with at least one of the days for each survey coinciding with the special lunar calendar days (Survey 1 – 10th, 11th, 13th November 2008; Survey 2 – 22nd, 23rd, 29th December 2008; Survey 3 – 18th, 19th, 23rd January 2009; Survey 4 – 18th, 19th February 2009). Any shops which were closed on one day were visited again as soon as possible until each survey was completed.

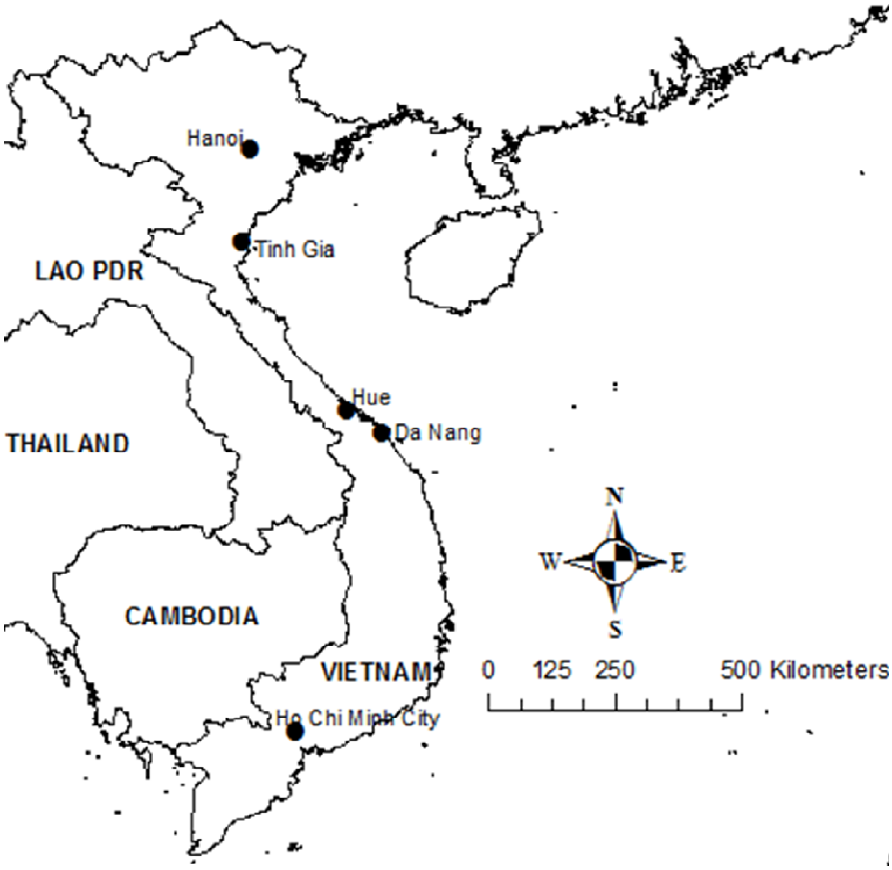

Figure 1 Map of Vietnam and neighbouring countries showing the five cities visited during 2009 surveys of Vietnam's ornamental bird trade.

Market surveys – outside Hanoi

Ornamental bird shops in the cities of HCMC, Hue and Da Nang and Tinh Gia town (Thanh Hoa province) were also surveyed (Fig. 1). The location of these shops outside Hanoi was determined by asking local people, bird keepers, internet searches for related newspaper articles and reports and liaison with conservation NGOs and staff from Saigon (HCMC) zoo. The methodology replicated that used in Hanoi's shops. Surveys in HCMC took place on the 7th and 8th January 2009; in Hue on the 11th February 2009; in Da Nang on the 1st and 2nd December 2008 and in Tinh Gia on the 11th December 2008 and 11th February 2009. For logistical reasons each shop was surveyed once.

Vendor interviews

With the help of a Vietnamese field assistant, all known vendors operating from permanent premises in Hanoi, HCMC, Hue, Da Nang and Trinh Gia were asked if they would answer a standard set of questions about their trade.

Semi-structured interviews were conducted with co-operating vendors. The interview questions (see thesis Appendix D for example questionnaire) sought to determine a) how the arrival of HPAI H5N1 in Vietnam had affected their trade, b) if income diversification methods had been employed by vendors during HPAI H5N1 outbreaks, c) how the ornamental bird trade had changed since HPAI H5N1 arrived in Vietnam, d) if selling ornamental birds was the main source of income for vendor households, e) consumer preferences of species and species' characteristics, and lastly, f) if vendors were aware of any regulations concerning the sale of ornamental birds. Research involving human participants received ethical approval from the University of East Anglia's international development research ethics committee. All interviews were recorded using a dictaphone and following the interviews the recordings were transcribed by both members of the interview team. During extraction the data were made anonymous and the original dictaphone recordings destroyed.

Statistical analysis

Market surveys

Mann-Whitney U-tests were used to compare a) the number of birds available for sale in different cities across Vietnam, b) the proportion of the trade made up of captive-bred species in 2007 and 2009.

The species communities within the OBMs in each of the areas surveyed were compared for similarity using pairwise ANOSIM (analysis of similarity) using the software PRIMER-e (Clarke and Gorley, 2006).

RESULTS

Comparing the ornamental bird trade in Hanoi across years

During our 2008/09 surveys we visited the same six markets identified during previous surveys (Morris 2001; Franklin 2005; Brooks-Moizer *et al.* 2008) as well two shops not previously located. In total seven OBMs were surveyed with a total of 40 shops. At any one time, the maximum number of shops selling ornamental birds in Hanoi was 38, with two shops sometimes only selling bird cages or pet food and no ornamental birds. Twenty five of the 38 (65.7%) shops in the January 2009 surveys sold poultry alongside

ornamental birds, typically keeping fewer than twenty birds in cages adjacent to the ornamental bird cages. Our surveys recorded a maximum of 9117 individuals of 43 species in January 2009

Taking into account the species known to be susceptible to HPAI H5N1 (thesis Appendix C) and assuming no bird is in stock for longer than one month, of the 36,584 birds counted across all of the 2008/09 Hanoi surveys, 28,158 (77%) were known to be HPAI H5N1-vulnerable species. Of the 66 species identified to species-level in Hanoi, 91% (60/66) are classed as species of Least Concern (LC) on the IUCN Red List 2009, with just one species (1.5%) from a threatened category (thesis Appendix C). Four species were identified by vendors as being primarily captive-bred namely Canaries, Spotted Doves, Java Sparrows and Budgerigars (Fig. 2).

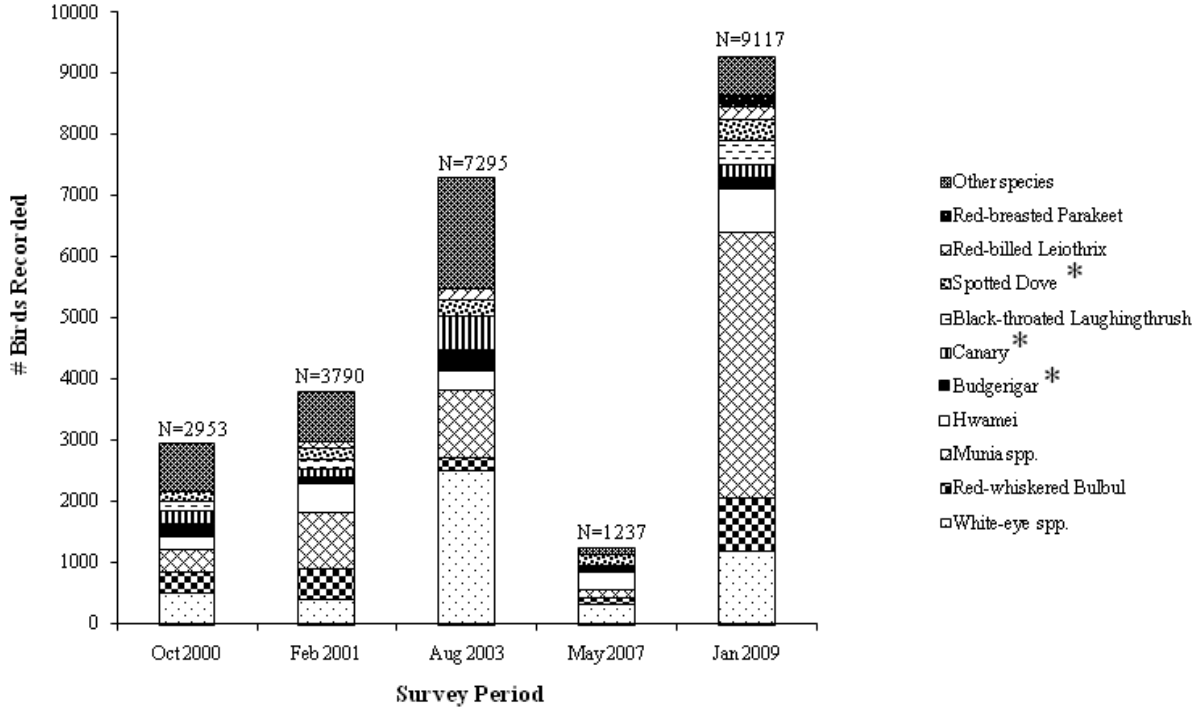

Figure 2 The ten most common species recorded during a survey of Hanoi's ornamental bird shops in January 2009 and the corresponding numbers of those species recorded during previous surveys. * - denotes a species reported by ornamental bird vendors to be captive-bred. Data sourced from Morris 2001 (2000 and 2001), Franklin 2005 (2003) and Brooks-Moizer *et al.* 2008 (2007).

Comparing the ornamental bird trade elsewhere in Vietnam

Seven permanent shops and two mobile vendors were surveyed in HCMC, seven permanent shops in Hue, 14 semi-permanent shops (each shop is always in the same place but are roadside stalls as opposed to permanent buildings) in Tinh Gia and two permanent shops in Da Nang.

Table 1 R-values from ANOSIM (analysis of similarity) pairwise tests comparing species composition and evenness across ornamental bird markets in different cities of Vietnam. ** denotes significant to the 0.001 level, * denotes significant to the 0.05 level.

CITY	Hanoi	Ho Chi Minh	Da Nang	Hue
Ho Chi Minh	0.491**			
Da Nang	0.186	0.453*		
Hue	0.173	0.088	0.688*	
Tien Gia	0.78**	0.7**	0.856*	0.763**

In total, at least 69 species were recorded across Vietnam's OBMs during the 2008/09 surveys, including the three Munia spp. and three other taxa which were not identified to species-level (White-eye spp., *Phylloscopus* warbler spp. and Lark spp.). The composition of species making up the trade varied across locations (Fig. 3). In particular the species composition in Tien Gia was highly dissimilar to that in all other markets ($R>0.7$, Table 1). Species composition in Hanoi was similar to both Da Nang and Hue whereas Ho Chi Minh City was moderately dissimilar to Hanoi and Da Nang (Figure 3; Table 1). Hue was intermediate between Ho Chi Minh City and Hanoi. The most diverse markets in terms of species richness and abundance were seen in Hanoi with the least diverse for species richness and abundance being those in Da Nang and Hue respectively (Figure 3; Table 1).

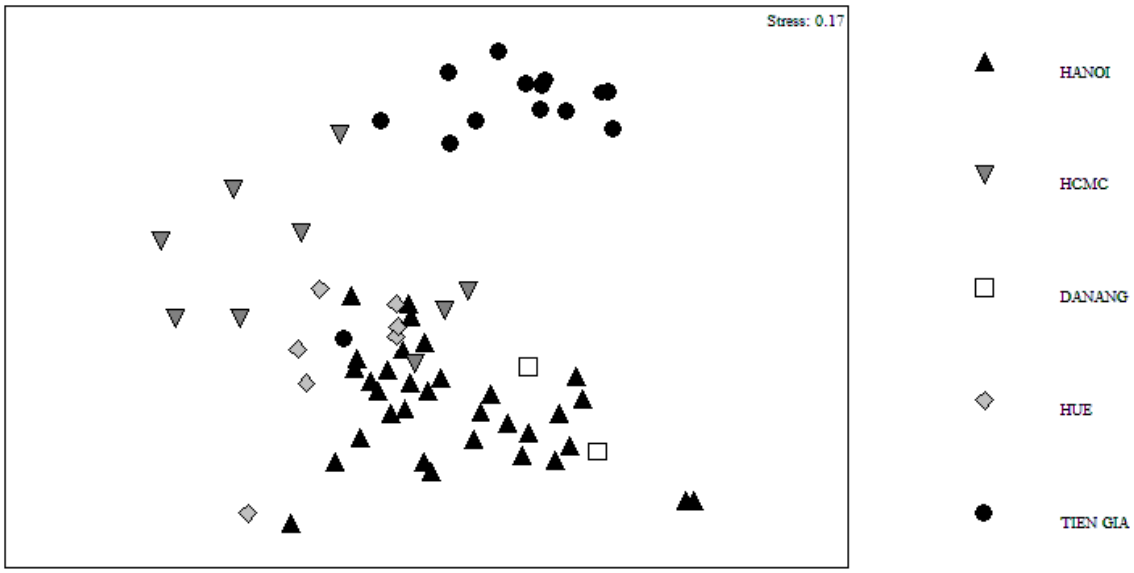

Figure 3 The ordination plot showing the relative similarity to each other, of the species assemblages within ornamental bird shops at five localities across Vietnam. The surveyed shops within each location are represented by individual symbols. Points clustered closer together are more similar in their species composition than those presented further apart. ANOSIM results; Global *R* = 0.557, *p* = 0.001.

More birds were available for sale within shops in Hanoi than in all other cities surveyed (mean number species per shop ± S.E, Hanoi 11.27 ± 1.02; outside Hanoi 7.88 ± 0.614, Mann-Whitney U-test, U = 348.5, *P* = 0.012, *n* = 66).

Vendor perceptions

Of the 33 ornamental bird vendors operating within Hanoi's six markets during the December 2008 surveys, 20 agreed to be interviewed (60.6% response rate). Both of the vendors operating in Da Nang (100%), six of the seven vendors in Hue (85.7%), eight of the 14 vendors in Tinh Gia (57.1%) and six of the seven vendors HCMC (85.7%) also agreed to be interviewed.

Selling birds was cited as the main source of income for the households of twenty one of the forty two vendors (50%) and a key income source for a further ten vendors (23.8%). Twenty seven of the 42 respondents (64.3%) were selling birds when HPAI H5N1 was first reported in Vietnam in 2003. Four vendors (9.5%) started their ornamental bird business since the introduction of Decree 69/2005/TT-BNN in 2005.

Of the 27 vendors selling birds when Decree 69/2005/TT-BNN was introduced, 22 (81.5%) reported having to stop selling birds for a period of time as a result of HPAI H5N1. Despite the legislation banning the trade in ornamental birds still being in effect, the modal time period which vendors reported ceasing to sell birds was 3-6 months with one vendor choosing to stop selling birds permanently. Of the 16 vendors in Hanoi who reported having to stop selling birds due to a ban, six (37.5%) reported that they resumed selling birds when the Government "told them that they could."

Within Hanoi, one vendor stated that he was aware of some restriction on which birds they could sell but was unable to say which birds this covered. The remaining 19 vendors stated that they were not aware of any restriction or regulations concerning which birds they could sell. Twelve of the 22 vendors (54.5%) outside Hanoi had some knowledge of the restrictions regarding the sale and transportation of ornamental birds.

All 37 of the vendors responding to questions regarding the source of their birds, reported buying birds sourced outside of the province where the birds were being sold. Thirty four of the vendors (92%) reported buying birds from several different areas. Three of the eight vendors in Tinh Gia named the provinces in which their birds were caught as Nghe An, a neighbouring province with moderate forest cover. Eight of the 42 vendors (19%) across Vietnam reported that the number of ornamental bird suppliers has increased since before bird flu reached Vietnam. Four vendors reported an ability to supply species at our request, providing we "order" in advance.

DISCUSSION

Our surveys found that since 2007, the ornamental bird trade in Hanoi has increased in terms of the number of individuals exploited by the trade. Bird markets in Hanoi stock more birds than elsewhere in Vietnam and also contain the highest diversity of species. A number of the species common to Vietnam's bird trade are known to be susceptible to HPAI H5N1 and this, combined with the large proportion of shops which sell poultry alongside ornamental birds and the distances over which birds are transported, increases the risk that the country's ornamental bird trade may provide a mode of transmission for HPAI viruses. Ninety-five percent of Hanoian bird vendors stated that they were

unaware of restrictions on the birds they can sell. Selling ornamental birds is a main source of income for the household's of almost three-quarters of the vendors questioned.

Trade volume

The volume of the ornamental bird trade in Hanoi has changed significantly with a five-fold increase in the number of birds being recorded in January 2009 compared to previous surveys in May 2007. The number of species and individuals recorded in the Hanoi shops in January 2009 was similar to the pre-HPAI H5N1 levels seen in the 2003 (Franklin 2005) surveys. When comparing our surveys with those from 2007 (Brooks-Moizer *et al.*, 2008) we find increases of 387% and 5% in the number of individuals and species respectively (Fig. 2).

It has been estimated that 60% of birds caught in the wild perish before international exportation (Iñigo and Ramos, 1991). Up to 36,584 birds were counted across the 2008/09 Hanoi surveys and taking into account birds which die before reaching the markets and those which are exported internationally, this is likely to underestimate the overall number of birds extracted from the wild. Despite the increase in trade volume seen in Hanoi, the number of species seen only increased by 5%. Seasonality is unlikely to account for the changes seen in the species composition of the trade across years as the most common species in the trade are species resident to Vietnam.

Trade across Vietnam

We found very few threatened taxa in Vietnam's OBMs (one species of 69, 1.4%) which does not reflect their representation among the country's native avifauna in which around 10% of the 822 species are classified in IUCN threatened categories (Warne and Tran, 2002; BirdLife International, 2008). This raises questions about how or if Vietnam's threatened bird species are being traded. Vendors reported being able to acquire less commonly traded birds at a customer's request so it is likely that they are present within the trade network. Two possible explanations are that the country's rarer birds are being traded out of Vietnam, perhaps by air, land or sea, or that they are not displayed openly within the shops. A study of the wildlife trader network in Quang Tri province, central Vietnam identified ten bird species being caught for the wildlife trade,

five of which were not seen in any of our surveys across Vietnam (Mahood *et al.*, 2008), suggesting there may be local, rather than wide-scale, demand for these species. Investigations in the northern Vietnamese province of Quang Binh found 74 wildlife traders, 23 of whom reported trading internationally with the remainder supplying the cities of Hanoi and Vinh (Roberton, 2004). In our survey, one vendor in Tinh Gia reported that Chinese buyers often visit his stall to buy birds to then transport by road to China. The same vendor also reported having friends who collect birds from Malaysia and Lao PDR for him to sell. It may be the case that the more difficult to source and probably more expensive of Vietnam's birds are being routed to China and other Southeast Asian countries via the well-developed international illegal wildlife trade networks.

Surveys in the mid-1990s found 18 shops in HCMC and 13 in Hanoi (Nash, 1994) whereas our surveys 15 years later found a shift to four-times as many OBMs in Hanoi compared to HCMC. Shops in Vietnam's capital city of Hanoi contained more individuals for sale than the shops elsewhere in the country as well as the highest species diversity. Species diversity was second highest in Vietnam's most populous city (GSO, 2008), Ho Chi Minh, with diversity in the markets of Tinh Gia, along the main highway to Hanoi, also relatively high. These three locations all have excellent road access to other areas of Vietnam as well as to other countries (by road to China, to Lao PDR from Tinh Gia and to Cambodia from HCMC). Hanoi and HCMC also both have international airports and HCMC has international trade links with Cambodia via the Mekong River. A combination of varied trade routes and high human population densities is likely to promote the diverse ornamental bird trade seen in these locations. The species composition of ornamental birds on sale varied across Vietnam and that on sale in Tinh Gia differed from that recorded at all other locations. Transport links, trade networks, consumer preferences and proximity to forest are likely to be the main factors driving these differences across localities.

The majority of live ornamental birds within the trade are reportedly sourced directly from the wild either as free-flying adults or as nestlings with captive breeding only being the major source for relatively few species namely budgerigars *Melopsittacus undulates,* cockatiels *Nymphicus hollandicus,* canaries *Serinus canaria,* some finch

species and most *Agapornis* lovebirds (Beissinger, 2001). On the Indonesian islands of Java and Bali, the popular practice of keeping ornamental birds as pets and for singing contests is threatening the long-term future of many songbird species (Jepson and Ladle 2005; TRAFFIC, 2008). The popularity of this practice in Indonesia has seen an increase in the number of songbird breeders and these owners breed a number of threatened and non-threatened species in captivity (TRAFFIC, 2008). Only one of Hanoi's ornamental bird vendors reported breeding birds themselves and it is likely that the captive breeding of these birds takes place in the households of non-vendors.

Bird shops and disease transmission

The government legislation (Decree 69/2005/TT-BNN) introduced to regulate the trade of wild and ornamental birds also includes clauses which ban the raising of poultry in urban areas as well as restrictions on the sale of poultry from infected areas and poultry known or suspected to be infected with an HPAI virus. Almost two-thirds of the shops surveyed in Hanoi in February 2009 sold poultry (primarily chickens, occasionally guinea fowl) alongside ornamental birds providing an optimal environment for the mixing of pathogens via direct contact or airborne transmission. Live bird markets in Hong Kong and Pakistan have previously been shown to contain HPAI H5N1 positive species (Promed Mail, 2007a; Promed Mail, 2007b; Promed Mail, 2008). Cages within Vietnam's OBMs are typically crowded with conspecifics and stacked on top of, and next to, cages containing other species. This arrangement contributes towards a stressful captive environment for the birds as well as promoting pathogen transmission both between and within species. The number of birds seen in the Hanoi surveys alone known to be susceptible to HPAI H5N1, the mixing of poultry and ornamental birds within Vietnam's OBMs, and the subsequent sale and transportation of these birds, suggest that these ornamental bird shops could contribute to the perpetuation and spread of pathogens such as HPAI H5N1.

Trade controls and legislation

To control the impact that the ornamental bird trade may have on pathogen transmission and wild bird populations, effective control measures need to be developed. Trade bans require enforcement and an understanding of local livelihood dynamics to be able to apply effective trade controls (Cooney and Jepson, 2006). In Vietnam, this would

necessitate enforcement and promotion of the existing legislation by a law-abiding enforcement agency coupled with education for bird vendors willing to adhere to any legislation. Legislation introduced in 2005 in an attempt to control the spread of HPAI H5N1 was suggested as responsible for the decline in the ornamental bird trade recorded in Hanoi in the 2007 survey (Brooks-Moizer *et al.*, 2008) but the scale of the trade has expanded since then despite the law still being in effect. Knowledge of the existing legislation and bird-related pathogen risks varies across the country. Over half of the vendors operating outside of Hanoi have some knowledge of the restrictions on their trade but only one of Hanoi's 20 responding ornamental bird vendors reported knowledge of or pretended to be aware of regulations. None of Hanoi's vendors reported the police confiscating any of their birds. We witnessed the police in Hanoi confiscating ornamental birds from mobile vendors who were operating their business on the pavement and, according to the police this was because the vendors were causing an obstruction for pedestrians. The fate of the confiscated birds is unknown.

Currently there is little other evidence that existing legislation is being enforced and due to the cultural importance and value associated to keeping ornamental birds in Vietnam, a new approach is required if this trade is to be regulated and the risks of pathogen transmission minimised. The vendors' ability to move and hide their birds at short notice, as exhibited during the early HPAI H5N1 outbreaks in Vietnam (Edmunds *et al.*, In prep) highlights the problems of controlling this trade and the disease threats it may pose.

CONCLUSION

We propose that the effective control of Vietnam's ornamental bird trade requires increased awareness and enforcement of legislation integrated with a programme of health surveillance for the live bird markets. Such a scheme would allow for effective monitoring of the markets alongside confiscations of illegal animals whilst also introducing a regular screening programme for the legally traded (primarily captive-bred) species already present within the trade system.

This is the first comprehensive study of Vietnam's illegal wild bird trade and we hope its results may inform effective control and monitoring of zoonotic EIDs and the conservation of Southeast Asia's avifauna.

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Chapter 4

Human-animal interfaces and highly pathogenic avian influenza strain H5N1: examples from Thailand and Vietnam.

Clockwise from top; songbird contest in Hanoi, cages of songbirds for sale at a Buddhist temple in Ho Chi Minh City, fighting cock contest in Chiang Mai. Photos by Kelly Edmunds and Nichar Gregory.

ABSTRACT

The current highly pathogenic avian influenza virus (HPAI) H5N1 panzootic is the most extensive and expensive animal disease ever recorded. Despite initial claims that migratory birds were responsible for virus transmission, evidence now implicates human-induced movement and trade of live birds as more probable transmission mechanisms.

Several factors unique to Southeast Asian countries promote pathogen transmission and complicate control at the human-animal interface. Through investigating cultural practices utilising birds, we explore how such activities may facilitate transmission of zoonotic pathogens such as HPAI H5N1.

We found that cultural exploitation of birds within Vietnam and Thailand offers a range of opportunities for pathogen exchange. Fighting cock and songbird competitions are male-dominated activities. Fighting cock owners consider their birds' health a priority and pay little regard to their own well-being when treating their birds. By contrast, religious merit release ceremonies are female-dominated with an expanding youth contingent in Southern Vietnam. These religious ceremonies within Vietnam are exploiting an estimated three to four million wild birds annually.

In addition to the direct transmission opportunities posed by these activities, the transportation of birds, combined with the mixing of birds of different origins, pose threats for the longer distance transportation of pathogens, particularly viruses such as HPAI.

INTRODUCTION

The current panzootic of highly pathogenic avian influenza virus (HPAI) strain H5N1 is the most extensive and expensive animal disease ever recorded (Zessin 2006; Dudley 2008). Currently circulating strains of HPAI H5N1 have been reported in species from at least 61 countries, causing a global loss of hundreds of millions of domestic poultry as well as 329 deaths from 562 confirmed human cases (58.5% mortality rate; WHO 2011). Migratory birds were initially blamed for the spread of viruses although more recent evidence now identifies the human-induced movement and subsequent trade of poultry and live birds as more likely transmission mechanisms for these viruses (Alexander 2000; Capua and Marangon 2006; Olsen *et al.* 2006; Gaidet *et al.* 2010).

Southeast Asia and the human-animal interface

A number of factors customary to Southeast Asian countries, such as Thailand and Vietnam, add to the difficulties of understanding the pathways of pathogen transmission, and thus their control (Webster *et al*. 2006). These factors include a widespread domestic and international trade in poultry and cultural practices which bring birds and people into close contact. Activities such as the release of birds for religious merit and cock-fighting may facilitate the spread of pathogens, such as HPAI H5N1 across species and geographic boundaries, whilst also promoting interactions at the human-animal interface (Karesh *et al.* 2005 Webster *et al.* 2006).

The relationship between birds and humans in Southeast Asia has a long history and in many parts of the region, bird-keeping forms an important part of local culture and tradition (Thomse *et al.* 1992; Nash 1994). In modern Thailand and Vietnam, the role of birds in urban and rural households frequently extends beyond that of domestic poultry providing a source of food and income. Across numerous Southeast Asian countries, male fowl are kept and trained for prestigious fighting-cock (FC) contests and wild songbirds are trapped and kept as pets, for prestigious songbird contests and also for use in religious merit release (RMR) ceremonies where participants believe that by "freeing" captive animals, they gain merit with the Gods in their current and future lives (Severinghaus and Chi 1999).

Evidence suggests the smuggling of FCs to be the most likely route of introduction of HPAI H5N1 into Malaysia (Sims *et al.* 2005). High densities of FCs within an area is known to present higher HPAI risks (Paul *et al.* 2010; Tiensin *et al.* 2009; Gilbert *et al.* 2006). Thailand has a long tradition of breeding chickens for FC contests and is a key participant for this activity within Southeast Asia. These contests are highly lucrative for both the breeders of champion birds as well as those gambling on the contests.

Conversely FC contests are less common in Vietnam although Vietnam has a long tradition of merit release practices involving birds. Merit releases of birds occur across both of these Buddhism-dominated countries. The release of animals in order to gain religious merit is common and widespread across Asia, particularly amongst communities with strong Buddhist influence (Chen 2006; Severinghaus and Chi 1999). Released animals pose threats to native wildlife in the countries of their liberation as both direct competition (in the case of introduced exotic species) and through the introduction of pathogens (Chen 2006; Severinghaus and Chi 1999).

The ornamental bird trade in Vietnam is undergoing a rapid increase with a greater number of species and birds being observed for sale (Edmunds et al. *in press*). The majority of birds in Vietnam's ornamental bird shops are small songbirds, the most numerous of which are munias (*Lonchura* sp.), the preferred species used during RMRs, and white-eyes (*Zosterops* sp.), the main species for songbird contests. Contrary to the bird trade in Bangkok where birds are chosen for their aesthetic appeal (Edmunds et al. 2011), the keeping of birds in Vietnam is dominated by singing ability; hence the preference for small songbirds. Songbird contests, where hundreds of small caged songbirds are displayed and judged for their singing ability, present another opportunity for the mixing of conspecifics transported from a wide area into one arena, as well as introducing another dimension to the human-animal interface.

This paper aims to fill current knowledge gaps in the role which human traditions and cultural practices may play in pathogen transmission. Specifically it aims to i) determine the potential that traditional and cultural uses of birds have for the transmission of zoonotic pathogens in Thailand and Vietnam; ii) increase our understanding of the beliefs behind these practices so as to improve management and monitoring of these

activities during periods of disease risk and iii) compare these practices in the urban centres of two key Southeast Asian countries; Thailand and Vietnam.

METHODS

Study regions

Thailand and Vietnam are two of Southeast Asia's most densely populated countries (129 people/km^2 and 285 people/km^2 respectively) with per capita GDPs of £5,200 and £1,850 (CIA World Factbook, 2010). The primary religion within both countries is Buddhism with 9.4% of Vietnamese claiming to be Buddhist (1999 Government census, CIA World Factbook, 2010) compared to 94.6% of Thai residents (2000 Government census, CIA World Factbook, 2010).

As this study involves human participants, ethical approval was received from the University of East Anglia's Research Ethics Committee prior to undertaking this research. To preserve respondents' anonymity, information which could identify individual respondents was recorded separately to SSI responses.

Across both Thailand and Vietnam data collection focused on key cultural practices involving birds within that country. For Thailand this was primarily FC contests and RMRs, in Vietnam this was primarily RMRs and songbird contests. Within both Thailand and Vietnam a range of techniques including semi-structured interviews, focal groups and key informant interviews were employed. All interviews were conducted in the local language and then translated into English by the bilingual interviewers.

Fighting-cock contests

FC contests occur openly across Thailand with a major hub for contests being the northern city of Chiang Mai. In order to understand the role, scale and format of FC contests as well as the relationships and risks for pathogen transmission, semi-structured interviews were conducted with 30 FC owners/breeders. Legal FC contests take place across four official arenas spread across the city, with each arena open on only one day every weekend. In addition to these legal contests, illegal fights occur outside of these times at other locations across the city. Our interviews were conducted with FC owners present at legal contests across three of Chiang Mai's main arenas.

For detailed information about the contests, veterinary care of FCs and the relationship between the FCs and their owners, key informant interviews were conducted with the

managers of contest arenas, a senior veterinarian and the head of a cultural cockfighting centre. In addition, specific data relating to the transportation and movement of the birds were collected at the FC arenas. All data on FC contests were collected during August and September 2010.

Religious merit releases

The practice of RMRs may vary between temple/pagoda and as such, has the potential to occur at any time of the month and year. To understand how RMR practices vary between temple/pagoda, we conducted a series of key informant interviews with monks at temples and pagodas, RMR participants and animal vendors. Temples within Thailand typically tend to be much larger and busier than those in Vietnam which made access to the senior monks particularly difficult and in addition, Thai monks never participate in RMR ceremonies. As a result, in Vietnam we interviewed 10 monks within Hanoi and 10 monks in Ho Chi Minh City and in Thailand we interviewed 10 monks, RMR participants and animal vendors across Bangkok, Nakhon Pathom, Ayuttayah and Suphan Buri. These discussions centred on understanding what happens during RMR ceremonies, the scale of RMR practices, beliefs behind RMRs and how they may contribute towards pathogen transmission. Interviews took place during August and September 2010.

In addition to the key informant interviews conducted with senior monks, structured interviews were conducted with RMR participants within Hanoi (Appendix E). These interviews formed part of a larger interview with a random sample of central Hanoi residents. The whole interview focussed on understanding the role of birds within central Hanoian households and how avian influenza may have affected these households. The interviewers asked questions about the role and importance of poultry within the household; the keeping of ornamental birds; knowledge of avian influenza viruses; behavioural changes associated with perceived risks of avian influenza as well as RMR practices. The person responsible for poultry purchasing and preparation from 406 households randomly selected across the four central Hanoi districts were interviewed. Only the responses relating to RMR practices are included in this paper.

Songbird contests

We identified the months and locations of Hanoi-based songbird contests by conducting online internet searches and speaking to wild bird vendors. At contests during November 2009, seven key informant interviews were conducted with the owners of competing songbirds and organisers of the contests. Topics covered during interviews included the reasons for and experiences of, contest participation as well as the impact of HPAI H5N1 outbreaks on the contests. All interviews were conducted in Vietnamese and translated into English with the exception of one interview, which was conducted in English.

RESULTS

Fighting cock contests

Within Chiang Mai, FC contests take place at four main arenas (Mae Yoi, Sankampaeng, Doi Saket and Mae Kheau) every weekend, apart from national holidays. Fights at Mae Yoi and Sankampaeng take place on Saturdays and those at Doi Saket and Mae Kheau take place on Sundays. Sankampaeng is Chiang Mai's most popular fighting arena with 95.2% of respondents reporting taking their birds there to fight (Figure 1). The most popular arena outside Chiang Mai, visited by our Chiang Mai-based respondents is in Lamphun, situated approximately 150km South-Southeast of Chiang Mai. The furthest location which any of our respondents went to in order to participate in a contest is Bangkok, more than 750km from Chiang Mai and visited by just one respondent.

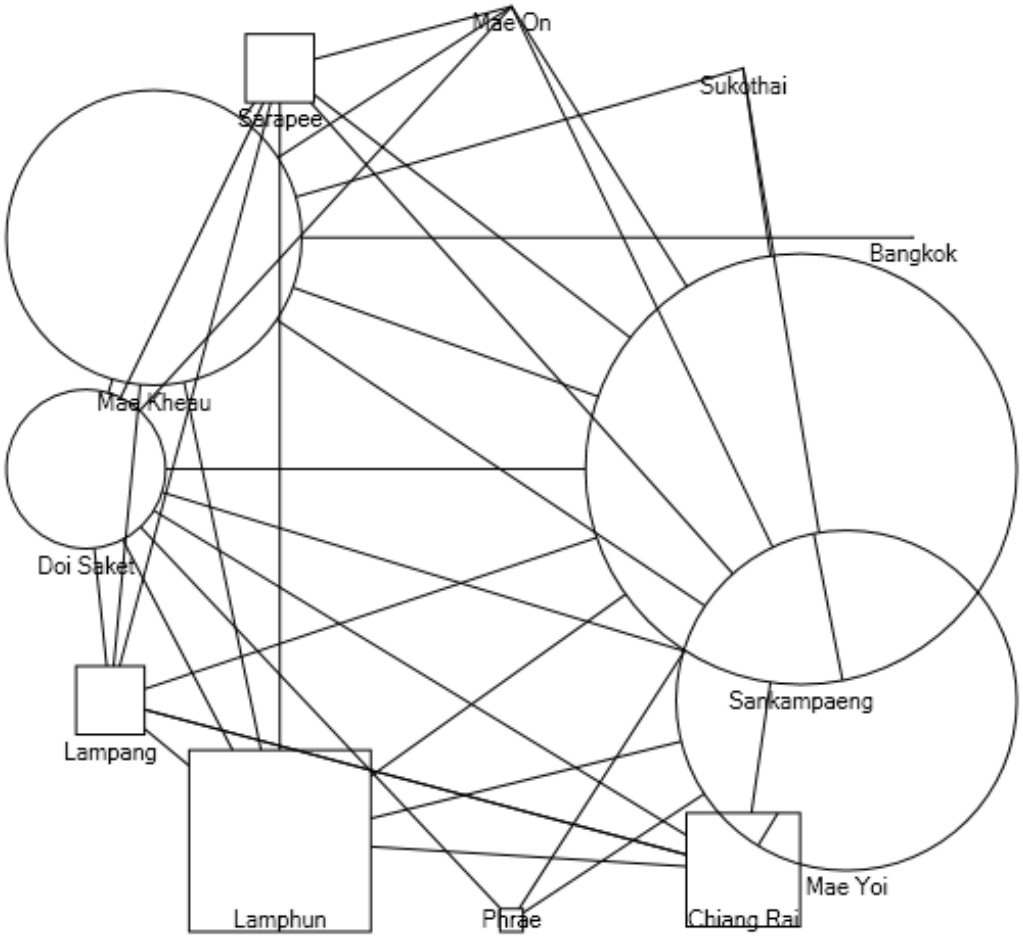

Figure 1 Social networking node graph of the fighting arenas at which Chiang Mai-based FC owners (*n=21*) reported taking their birds for contests during the previous six months. Circles represent the main arenas within Chiang Mai, squares represent all other arenas reportedly visited across Thailand. Shape size is proportional to the number of respondents reporting their birds fighting at that location.

Average age of the respondents was 47 years and they have been participating in FC contests for an average of 21 years. All respondents breed FCs and the majority (66.7%) participate in fighting contests at least once/week with the remainder participating twice a month (13.3%) or once/month (20%). The majority of owners (60%) fight each bird just once/month whilst some owners rest their birds for up to 3 months between contests.

Respondents typically keep fewer than 40 fighting birds (mean ± SE, 37 ± 8 fighting birds) with six respondents (20%) keeping non-fighting poultry (mean ± SE, 82.5 ± 25.2 non-fighting birds) alongside their fighting birds. Almost all respondents (90%) train

their birds through practice fighting contests amongst their own flock with the remainder buying birds specifically to use in training bouts.

When asked how much money could be won on a fight, responses ranged from 1,000 Thai baht (£21 GBP) to over 1,000,000 baht (£21,000 GBP) for winning a fight at an important event. The mean average prize money was just under 50,000 baht (£1,050 GBP) with one third of respondents reporting sums greater than 50,000 baht as the usual amount they took away from a fight. The largest sum of money reported to have been won by any of our respondents on a fight was 750,000 baht (£15,775 GBP) with the average being just over 90,000 baht (£1,890 GBP).

The majority of owners (90%) vaccinate their birds against common poultry diseases with greatest concern being given to avian influenza, Newcastle disease and fowl cholera (Table 1). *"Yes, [I vaccinate them] against Newcastle disease – it kills a lot of birds. Then bird flu came along and you had to dip all your bird's feet in medicine before entering the arena. It really depends what disease is around. If something is affecting birds at a certain time, then you vaccinate against that. If not then there's no need."* respondent MK7, 58 years old. The remaining three owners declined to answer the question. One respondent reported giving *"...seven to eight different vaccines to each bird."* MK13, 40 years old. When asked how they treat injuries sustained during a fight, such as cuts, 90% of FC owners reported sewing cuts up and treating the injuries themselves. Treatments reportedly given to birds during a fight include administering medicine or tablets, burning hemp and lemongrass to then cover the bird in the smoke and sucking blood out of the bird's throat or wounds. *"Some people still suck blood out of the bird's cuts."* MY2, 38 years old.

Sixty percent of FC owners reported that avian influenza outbreaks have affected them or their birds. One third of the FC owners affected by avian influenza had birds die as a result of HPAI H5N1 outbreaks and the remaining FC owners reported having to vaccinate their birds, move them as a result of HPAI outbreaks or generally reported *"Avian influenza affected everyone with fighting cocks."* MY3 and 4, 50 and 40 years old; MK7, 58 years old; SKP5, 50 years old, (Table 1).

Table 1 Summary of the responses given, with sample statements, during interviews with the participants of fighting cock contests within Chiang Mai, Northern Thailand, September 2010.

Fighting cock culture	Disease prevention	Impacts of diseases
"There may be one fighting cock owner, but at fights there are usually at least 4 people tending to the bird. You can't do it alone! – one person needs to get water whilst the other one sews...etc." *MY7, 50 years old*	"Since bird flu, every fighting cock owner has to have a passport for each of his chickens...If you don't have a passport, you can't compete." *MK11, 47 years old*	"[Bird flu] has affected me because no one would buy chickens. I also had to move all my chickens if anyone in the area had a chicken die from bird flu." *MK9, 37 years old*
"Before, fights only happened in moo bans (small housing compounds/villages), but it's very popular now and happens in the cities." *SKP3, 58 years old*	"No, I'm not scared of it [bird flu]. It hasn't happened here. Still, we had to vaccinate the birds against it when they were little." *MY5, 62 years old*	"The fighting cocks aren't well these days, sometimes they have to rest for a year. H5N1 is still around." *MY10, 68 years old*
"I sell them mainly to people from Thailand, but I sometimes get Japanese or other nationalities buying cocks. I also send eggs to Kazakhstan!" *MK11, 47 years old*	"The big arenas have to clean up [between fights], but the small ones don't. During bird flu there was lots of cleaning. You had to walk through this disinfectant before entering the arena." *SKP3, 58 years old*	"People who are fighting cock owners know when their birds are sick. You can tell how well they are from their faeces and how long food stays in their throat." *MY3, 50 years old*
"...it's my bird's 94th time fighting." *SKP7, 66 years old*	"They don't allow a bird flu vaccine here." *SKP1, 40 years old*	".....during H5N1 it [cock fighting] stopped completely." *MY2, 38 years old*
"…if they run away once [during a fight], then they will always run and can't compete anymore. Then I have to sell them as meat" *MK11, 47 years old*		"You have to be careful because as soon as your bird is sick, even if it gets better, it won't fight the same as it did before – it's a lost bird." *MY3, 50 years old*

Religious merit releases

Key informant interviews

The key informant interviews revealed a number of differences in the beliefs behind RMR practices and how the ceremonies take place (Table 2). Some of the most notable differences were seen between Hanoi and HCMC as well as between Vietnam and Thailand.

The differences seen between Hanoi and HCMC appear to stem from differences in perceptions of Buddhism between North and South Vietnam. In HCMC we were often told how Buddhism is introduced to people at a younger age than in the North of the country. Two of our key informants attribute this to the strong Chinese influence within Southern Vietnam and subsequently, a greater influence of Buddhism over people's lives. *"It's obvious that the Chinese culture has influenced people in the South more than in the North, so people in the North are less familiar with merit releases"* respondent HCMC10. Likewise, the Hanoi-based key informants agreed that RMR is more popular in the South of Vietnam compared to the North.

An important difference in RMR ceremonies between Vietnam and Thailand is that many Thai vendors report that it is illegal to sell birds for releasing and that releases cannot take place inside many of the temples. *"In Thailand, it's illegal to sell birds for release. Releasing them isn't illegal though. It's been illegal for about eight years now"* respondent AY01. This was also supported by a respondent in another area of Thailand who said *"It's illegal to sell them [birds for merit release], but we trust people not to tell the Forestry Department as we are helping the people who need to release birds, therefore they will not report us."* respondent SP03.

A key difference between Hanoi and HCMC is in the impact that HPAI H5N1 had on RMR practices. In HCMC all monks talked about HPAI H5N1 reducing the frequency of RMR ceremonies with seven monks specifically recalling a ban that was introduced to stop RMR ceremonies involving birds. None of the monks in Hanoi reported HPAI H5N1 having any impact on RMR ceremonies in the North, with several monks believing HPAI H5N1 is only a problem for domestic poultry. A decline in the number of vendors selling birds for RMR in front of pagodas was also noted *"There used to be*

tens of sellers in front of the pagoda but now there are just several" respondent HCMC02.

In Thailand"*...during bird flu people were not allowed to sell or release them [birds]"* respondent AY01. Several key informants made similar statements, although few of them stopped selling birds for RMR during HPAI H5N1 outbreaks. The level of concern given to HPAI outbreaks seems to vary from person-to-person with respondent BKK01 reporting *"...During bird flu I chased away the munia birds from the pier...I was scared of bird flu! So were the people in the temple – they wouldn't let me keep pet birds anymore!"* whereas respondent BKK02 told us *"I wasn't scared of bird flu when it happened. I used a mouth cover though and washed my hands after handling the birds – just to be safe. ...Many people were scared of HPAI though and I didn't sell as many [birds] as before."*

Across all locations, when a pagoda or temple is situated near water, fish, turtles and snails are reported as the most popular animal for RMR. At pagodas or temples without water, birds are the most popular animal for RMR ceremonies. Informants in Thailand revealed that the animals released varied with the reason for the release. Animals with shells (e.g. snails, crabs) are released for reasons associated with money; animals which move in a flowing manner (birds and eels) are released to represent freedom from problems; frogs are released when people want to move forwards in their life as Thai people believe frogs are unable to move backwards (N. Gregory, Pers. observation.).

Table 2 Factors relating to the practice of religious merit release (RMR) ceremonies as reported by key informants across the main cities of Vietnam and Thailand, 2010. The details presented are those reported by all, or the majority of key informants, interviewed within each city.

	Hanoi	Ho Chi Minh City	Thailand
Ceremony location	Temples, pagodas	Temples, pagodas	Anywhere
Ceremony timing	Festivals and when people ask for it	Festivals, 1st and 15th of lunar calendar and when people ask for it	Festivals and when people ask for it
Ceremony participants	Primarily middle aged and elderly females	Anyone, but increasing numbers of younger people	Anyone but particularly traditional Buddhists
Reasons for participating	Luck, blessing for themselves and/or family	Luck, blessing or dependent origin (the Buddhist belief that everything is connected)	To release troubles, encourage progress/success
Main animals released	Birds, fish, turtles, snails, crabs,	Mainly birds and turtles	Fish, eels, turtles, birds
Reason for choice of animal	Smaller animals chosen if lots need to be released		Dependent on reason for release
Numbers of animals released	Varies with reason for RMR and age of releaser	Varies with reason for RMR	Varies with reason for RMR and age of releaser
Where are animals purchased?	Market/shop	Market or in front of pagoda	Market, stall close to temple
Do monks bless animals?	Y, always	Not always	Never
Impact of bird flu on RMR	None. Perceived as an old problem affecting only domestic poultry	Y. Ban on RMR for "a while." Police confiscated birds.	Very little, mostly regarding hygiene whilst handling birds
Perceived change in number of participants since bird flu began?	Increased	Decreased	No change

Central Hanoi RMR participants

Four people was the average household size of the 406 households surveyed, giving a total extrapolated sample population of 1856 Hanoians. From these 406 households, 80 (19.7%) reported at least one person in the household participating in RMR ceremonies. All participants were female, with each age class well represented (18-29 years 23.8%; 30-44 years 30%; 45-59 years 20%; over 60 years 26.2%). The majority of those participating in RMR practices (68.8%) are currently full-time housewives (23.8%) or in unskilled employment (45%).

Seventy three of those participating in RMR ceremonies stated which animals they release during ceremonies (Figure 2), the seven remaining respondents vary the animals they release with the reason for RMR participation. The majority of respondents (65.8%) have participated in RMR ceremonies for only one type of animal, 9.6% have released two types of animal and the same number, 12.3%, have released three or four types of animals. Birds were the most commonly released animal (Figure 2) with approximately 100 birds (mean ± SE, 103.5 ± 19.3) released in each RMR ceremony. The number of birds released varies with factors such as the age of the person being prayed for and the purpose of the ceremony.

Given a total central Hanoi population of 1,079,487 (GSO 2008) and an average household size seen in this survey of four people/household, we estimate there are 269,871 households within central Hanoi. Taking into account that 19.7% of our survey households include at least one RMR participant, an estimated 52,624 central Hanoian households participate in RMR ceremonies. Fifty two percent of RMR participants release birds and partake in one-two ceremonies per year giving an estimate of approximately 27,364-54,728 birds released during religious merit ceremonies within central Hanoi each year. A conservative estimate based on these figures would be 35,000-40,000 birds released in central Hanoian RMR ceremonies annually.

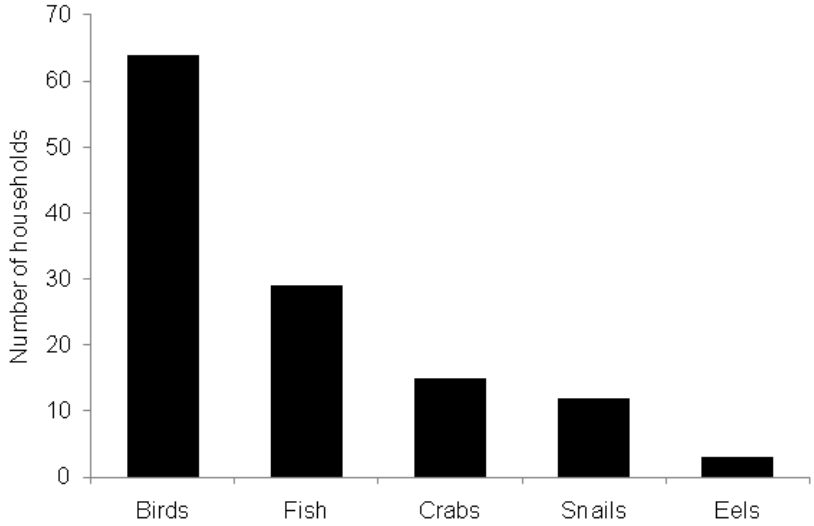

Figure 2 Animals reportedly released during religious merit release (RMR) ceremonies in Hanoi (total *n*= 406 households, 80 of which reported participating in RMR ceremonies).

Five of the households participating in RMR ceremonies (6.3%) reported changing their participation in RMR ceremonies as a result of HPAI. Four of these participants temporarily stopped partaking in RMR altogether when they perceived HPAI to be a serious problem in Vietnam. The fifth participant switched from releasing birds to releasing fish.

Songbird contests

Songbird contests take place seasonally within Hanoi *"...there are only four or five competitions a year in Hanoi.....they have just revived songbird competitions in Hanoi about three years ago so they are not too many opportunities to compete."* Male, 20-25 years of age. During November 2009, two songbird contests were attended in Hanoi which had approximately 130 and 80 caged White-eyes (*Zosterops* spp.) respectively. The birds were primarily transported to the contest in their cages, held by passengers on the back of motorbikes. Those attending the contests, both as competitors and observers, primarily come from within Hanoi. Many of those attending the contests we visited also attend contests in other Northern provinces including Hai Phong (approximately 120km from Hanoi), Bac Ninh (approximately 35km from Hanoi), Nam Dinh (approximately 90km from Hanoi) and Quang Ninh (approximately 230km from Hanoi).

Table 3 Summary of the responses given, with sample quotes, during interviews with the owners of songbirds participating in singing contests within Hanoi, November 2009.

Culture of keeping competing songbirds	Reasons for participating in contests	Impact of HPAI H5N1 on contests
Long history, prestige,	Enjoyment, pride, socialise, to learn	Released birds, transferred birds out of the city, stopped keeping birds, no impact.
"...I love keeping ornamental birds for a long time. It has become a habit of mine and my day wouldn't be complete if I didn't bring the cages to the door step of my house, drink some tea and listen to these two lovely birds singing." *Male, over 60 years old.*	"I take part in this competition just to meet other men with the same hobby, to see how my bird can perform in front of the judges and I hope he'll make me proud." *Male, 35-40 years old.*	"I used to have more Red-whiskered Bulbuls and some other White-eyes several years ago but I had to release them when there was a bird flu outbreak. That incident made me avoid keeping birds for a long time but I missed this hobby so when the outbreak was over I started to keep songbirds again." *Male, over 60 years old.*
"I like keeping and listening to songbirds. Sometimes my White-eyes sing so loud that they actually out-talk my wife! Keeping ornamental birds is the kind of hobby that grows on you." *Male, 50-55 years old.*	"White-eyes are quite cheap but the winning one can be sold for over 10 million Vietnam dong (over 500 US$) ...I don't compete for money but I know some men would." *Male, 50-55 years old.*	"I've been keeping birds since I was young. The only time I had to stop was due to the outbreak of bird flu. I gave my birds to my relatives in the countryside at that time. I didn't want them to be culled since they were perfectly healthy." *Male, 50-55 years old.* "During 2005 and 2006, these songbird competitions were banned because of bird flu but now there's no reason to stop contests like this." *Male, over 60 years old.*

DISCUSSION

Southeast Asia has seen the emergence of several zoonotic diseases in recent years (e.g. Nipah virus in 1999, severe acute respiratory syndrome (SARS) in 2002) which have resulted in increasing media attention and public awareness being given to the relationships between live animals and humans (Burgos and Burgos 2007). In addition to HPAI viruses, pathogens such as Newcastle disease and West Nile Virus are known to affect wild bird populations and transmit virus to humans (Tsiodras *et al.* 2008). Activities which bring humans into repeated contact with live bird species can result in the transmission of pathogens from birds to humans, and vice versa, as well as between conspecifics or different avian species. All of the bird-exploitation activities investigated during this study pose risks for the local transmission of pathogens with potential for more widespread, international transmission.

The human-animal interfaces exposed through the exploitation of birds present a range of opportunities for pathogen transmission, both between animals and from animal to human. The exploitation of birds within Vietnam and Thailand involves numerous activities, many of which are gender-specific and accessible by all social and age classes. Exploitation activities typically vary both between and within these two countries. FC and songbird contests are male-dominated activities which pose differing risks for pathogen transmission. By contrast, religious merit release ceremonies are primarily attended by middle-aged and older females with a growing youth contingent becoming involved in the South of Vietnam. Owners of the FCs consider the health of their FCs to be a priority, often putting their own health at risk in the treatment of their birds. In addition to the direct transmission opportunities posed by these activities, the transportation of birds, combined with the mixing of birds of different origins, pose threats for the longer distance transportation of pathogens, particularly viruses such as HPAI.

Fighting cock contests

Whilst Thailand has experienced relatively few HPAI H5N1 outbreaks since the major epidemic waves of 2004, the outbreaks occurring since then are thought to have associations to the trade in live poultry and backyard poultry farmers participating in FC contests (DFID 2010). Within Chiang Mai, participation in FC contests is very much

dominated by middle-aged men who are passionate about their birds and participate in the contests as a long-term hobby. The contests can be financially lucrative for the owners of champion birds with prize money in the thousands of pounds often reported; substantial sums in a country with an average GDP of just over £5,000 (CIA World Factbook 2010).

Vaccination against avian influenza is prohibited within Thailand with preference instead given to the "stamping out" approach to HPAI H5N1 outbreaks (Petrini 2007). Despite this prohibition, precautions protecting FCs from numerous avian diseases are commonplace and several FC owners reported vaccinating their birds against many common poultry diseases, including avian influenza. Despite the introduction of FC passports to regulate the transportation of fighting cocks, in a country with an estimated 15 million FCs (Taipei Times 2005), regulating and monitoring veterinary care is a mammoth undertaking.

The structure of these contests and the environment in which they take place promotes pathogen transmission both between birds and from birds to humans. The close contact promoted during a prolonged fight between two birds which are likely weakened, injured and exhausted creates a model environment for pathogen transmission between birds. It is also worth noting that several consecutive fights take place within one fighting pit each day and the pit is not cleaned between bouts (N. Gregory, Pers obs.).

From the perspective of the human-animal interface, perhaps the most alarming finding of this aspect of the research is the large proportion of FC owners who treat their birds' injuries themselves and consequently, regularly put their health at risk for the sake of their birds. Performing acts such as sucking the blood from wounds or the throats of injured birds places the owner in a high risk position for the transmission of numerous pathogens.

In terms of reaching the greatest numbers of FC owners, campaigns targeting veterinary care or knowledge awareness would benefit from visiting the popular Mae Yoi and Sankampaeng arenas. Sankampaeng arena differs from Chiang Mai's three other arenas in that it is the only arena to have air conditioning (N Gregory, pers. obs.). In a tropical

climate such as that of Northern Thailand, an air conditioned arena is likely to appeal as an indoor venue at which to spend several hours. Attracting larger crowds has the potential to bring in greater revenue through the gambling that takes place with each contest.

Religious merit releases

Differences in merit release ceremonies and the beliefs behind RMR practices were observed across the two countries and between North and South Vietnam. These differences may be driven by the history and introduction of Buddhism within those regions and the influences of different Buddhist ideologies (Dinh *et al.* 2008).The concept of releasing animals from suffering is one which carries throughout much of traditional Buddhism (Dinh *et al* 2008) but we found that its interpretation varies depending on the teachings of individual monks.

The main bird species involved in RMR within Thailand and Vietnam are similar to those seen in previous surveys of merit bird markets in Phnom Penh (WCS 2007). As noted by Chan 2006, the birds used for RMR ceremonies typically lack attractive plumage and beautiful song and as such, are not in demand as pets or for songbird contests. Many of the bird species commonly released during these merit release ceremonies have been found to carry avian influenza viruses, including the highly pathogenic H5N1 strain (*Lonchura* spp., Hong Kong Government 2007) and Newcastle disease (Eurasian tree sparrows *Passer montanus*, WCS 2007). The Eurasian tree sparrows were collected from shrines within Phnom Penh, Cambodia and were for sale as merit release birds.

The conservative estimate of 35,000-40,000 birds released annually during merit releases within central Hanoi is approximately a third of that estimated in a survey of Taichung City (Chen 1995), and approximately 5% of the birds counted passing through merit bird markets at two large shrines in Phnom Penh over a 14-month period (WCS 2007). A recent survey (Chan 2006) of organisations participating in RMR ceremonies within Hong Kong estimated approximately 175,000 birds to be released across 250 ceremonies. Hong Kong has a population of approximately seven million people (CIA World Factbook 2010) giving approximately 0.025 birds released/person/year. The

population of central Hanoi is slightly over one million people (GSO 2008), giving a greater number of birds released per capita at approximately 0.035-0.04 bird released/person/year. If we were to extrapolate these figures for central Hanoi across the whole of Vietnam, using the lowest estimate of 35,000 birds released annually gives greater than 3,000,000 birds released each year. This figure is clearly an estimate that should be interpreted with caution as central Hanoi is not necessarily representative of the whole country but this is somewhat counterbalanced when considering that RMR practices reportedly occur more frequently in southern Vietnam. It is also important to take into account that some birds will be re-caught post-release and put back into the trade. When considering all these factors, as well as accounting for mortality rates between the point of capture and point of sale (estimates of pre-export mortality alone range from 30% - 55%, Nash 1990; Iñigo & Ramos 1991) we estimate that 3-4 million of birds are caught each year to supply the demand for RMR ceremonies in Vietnam.

Songbird contests

The short songbird contest season in Hanoi is largely due to the weather and avoidance of the hot, humid summers, monsoon season and cold winters. The songbird contests within Hanoi appear to operate in a similar way to those previously noted in Thailand and Singapore (see e.g. Nash 1994) albeit involving different bird species. As has been reported for contests elsewhere in Southeast Asia (see e.g. Nash 1994, Jepson 2008), songbird contests in Hanoi offer the owners of the competing birds a socialising opportunity whereby prize winning birds can bring them wealth, prestige and elevated social standing. These factors, combined with the enjoyment, lead to songbird owners travelling substantial distances in order to attend and enter their birds into contests.

These contests provide opportunities for indirect interactions between animals and humans with limited scope for frequent direct contact and as such, are a minor zoonotic disease transmission risk for humans. Perhaps the greatest risk they may pose for pathogen transmission is with the mixing of birds from numerous localities at one contest. This presents opportunities for bird-bird pathogen transmission, primarily during transportation to/from competitions and when birds are closely packed together in the early stages of the contest. However, despite the mixing of birds from several

localities, songbird contests on the whole occur on a relatively small scale and currently present little risk for pathogen transmission.

CONCLUSIONS

A key theme common to all activities covered in this paper is that the participants care more for the birds and the enjoyment of the activity than they do for any health risks posed to themselves. This is particularly important when considering the lengths which FC owners go to when caring for their competing birds such as licking wounds on the birds and sucking blood from their beaks/throats.

The number of birds which we crudely estimate to be released each year through Vietnam's RMR ceremonies is substantial. This figure gives cause for concern for wildlife conservation and ecosystem health reasons as well as promoting contact between birds and humans at an understudied human-animal interface. The impact that RMR ceremonies may be having on ecosystem health and wild populations of the numerous taxa involved warrants urgent research and investigation.

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Chapter 5

Risky livelihoods: why persist with poultry during disease pandemics?

Typical household yard in rural Quang Ninh province. Photo by Kelly Edmunds.

ABSTRACT

The keeping of backyard poultry requires minimal investment, land and training and as such, poultry species provide a valuable source of food and income to many low-income, rural households, particularly in developing countries. Disruption to poultry production systems, such as disease outbreaks, may result in wide-ranging impacts on food production and livelihood security, with the greatest effects felt by rural backyard poultry farmers.

Poultry breeding is widespread in Vietnam where large proportions of the human population live in rural areas and partake in backyard poultry production. Since highly pathogenic avian influenza (HPAI) strain H5N1 resurfaced in Southeast Asia in 2003, millions of birds have been lost to infection and outbreak control from large-scale industrial production facilities through to small-scale backyard poultry farmers. Households experiencing losses of their poultry flocks may find themselves having to adopt alternative strategies to ensure livelihood and food security. The adoption of alternative livelihoods depends on the role and utilisation of poultry within these households.

In order to investigate the role of poultry as a resource utilised by rural Vietnamese communities, we conducted a survey with 218 households across two Vietnamese provinces. Focusing on outbreaks of HPAI H5N1, we examined how disease outbreaks have affected the livelihoods of rural Vietnamese backyard poultry keepers and their subsequent responses to these outbreaks. We found that the majority of households surveyed participate in backyard poultry production; principally keeping poultry for household consumption with a preference for chickens over ducks. Households reported livelihood instability as a result of HPAI H5N1 outbreaks with the majority of those affected choosing to persevere with backyard poultry production rather than switch occupation. We also report on the role of poultry within rural households and the resilience of poultry farmers to disease shocks which may affect their flocks.

INTRODUCTION

Global estimates predict that poultry will contribute approximately 40% of total human consumption of animal protein by 2015 (IFPRI 2000). Poultry species are valuable sources of food and income for many poor rural families, particularly within low income, food-deficit countries, since they require less investment, labour and land than larger livestock (Sonaiya 2007). The keeping of backyard poultry is one of the few livelihoods in which the rural poor can partake even when lacking resources such as land, capital and education (Branckaert and Guèye 2000; Sonaiya 2000).

HPAI H5N1 resurfaced in Southeast Asia in 2003 and has since devastated poultry flocks across large parts of the region (Olsen *et al.* 2006; Thorson *et al.* 2006; Hong Hanh *et al.* 2007). In 2003, shortly before the current HPAI H5N1 panzootic reached Vietnam, it was estimated that there were 254 million poultry birds across the whole country and this figure had declined by approximately 15% by 2005 (Hong Hanh *et al.* 2007). Poultry breeding is widespread in Vietnam where approximately 80% of the human population lives in rural areas (Thorson *et al.* 2006). Poultry provides almost 80% of rural Vietnamese households with a potential year-round valuable source of protein as well as financial income through backyard and garden-raised flocks (Otte *et al.* 2006; Thorson *et al.* 2006; Hong Hanh *et al.* 2007).

Participating in backyard poultry production is a risky business due to unpredictable markets and economies, unstable weather events and the risks of disease outbreaks (Eklan 1998; Oparinde & Birol 2008). Disturbances to poultry production systems, such as disease outbreaks, will have wide-ranging impacts with the greatest effect felt by low income rural communities. Maintaining a livelihood which can withstand the shocks and stresses of pursuing risky activities (widely known as sustainable livelihoods see e.g. Ellis 2000) is essential for ensuring future household livelihood security and stability (Devereux 2001).

The current HPAI H5N1 epidemic is not only a public health problem (Kilpatrick *et al.* 2006) but also has economic impacts for many of the Vietnamese who live in rural areas (Thorson *et al.* 2006). The implementation of disease control measures following HPAI H5N1 outbreaks has resulted in the culling of millions of domestic poultry found within

the quarantine zones established around outbreak sites (OIE 2011). These disease control measures, whilst essential in controlling the spread of the virus, are depriving households of valuable protein in their diet, cash income and, most importantly, an investment opportunity to escape poverty (Epprecht *et al.* 2007). In order to manage the risks that participating in backyard poultry production poses to livelihoods, backyard poultry farmers need to make difficult choices and employ risk mitigation behaviours and strategies so as to maintain or regain food security (Sonaiya 2000).

This paper investigates the importance of poultry as a resource exploited by rural Vietnamese backyard poultry keepers and the risks involved in participating in this production system. We examine the role of poultry within rural households as a source of food and income and the resilience of poultry farmers to disease shocks affecting this system. Using HPAI H5N1 outbreaks as a case study, we then consider how these disease outbreaks have affected the livelihoods of rural Vietnamese backyard poultry keepers and their response to these outbreaks.

METHODOLOGY

Sampling

This study focuses on rural households within the provinces of Quang Nam and Quang Ninh (Figure 1). Within these two provinces, communes which had reported outbreaks of HPAI H5N1 in the previous three years were visited, the provincial People's Committee approached and permission obtained for conducting our research. With the help of officials from local Departments of Animal Health (DAH), villages experiencing HPAI H5N1 outbreaks in the previous three years were visited and a household survey conducted.

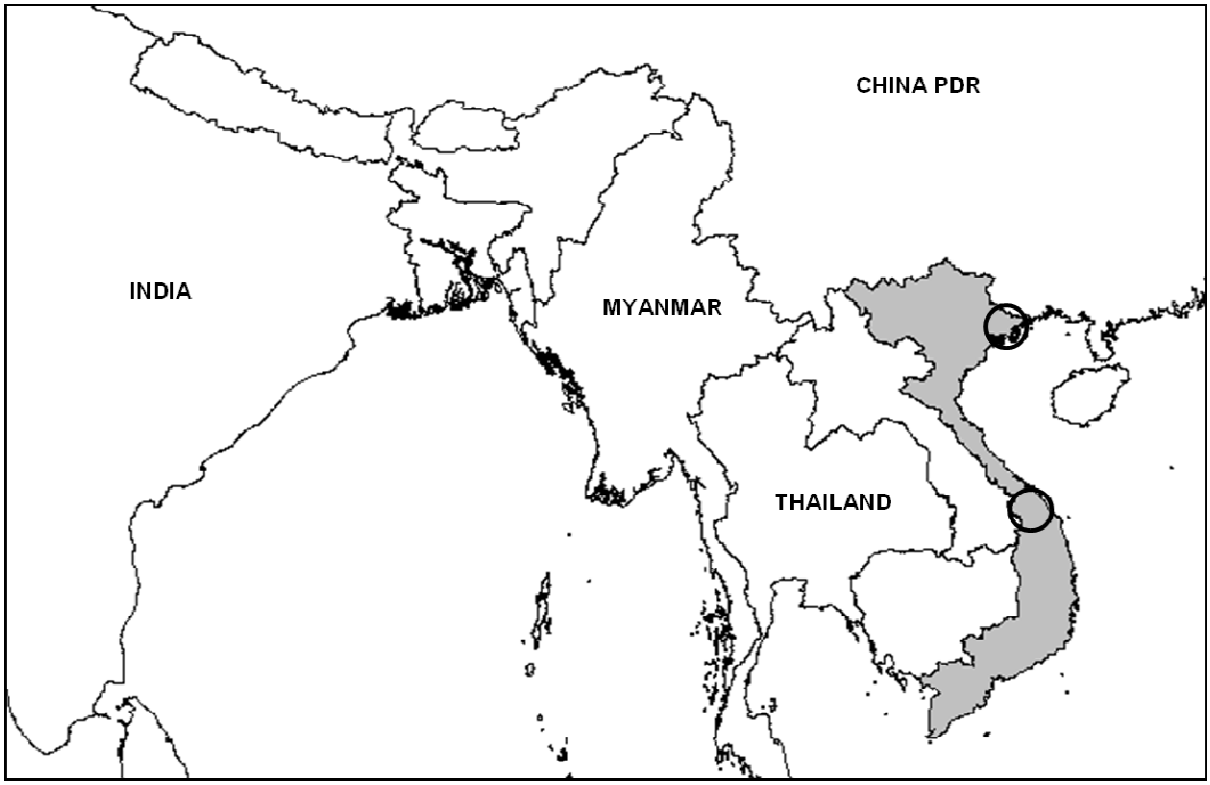

Figure 1 Map showing the location of Vietnam (shaded) within Southeast Asia and the provinces of Quang Ninh (northernmost) and Quang Nam. Five communes within each province were sampled during a household survey investigating the impacts of highly pathogenic avian influenza on rural poultry-keeping communities.

During surveys within Quang Nam in November 2008 and Quang Ninh in January 2010, the local DAH officials provided information regarding the impacts of HPAI H5N1 in the villages as well as a tour which included an introduction to the head of each village. Typically the DAH official(s) would accompany the household survey for the first morning of surveys and then leave; occasionally they accompanied visits to all households surveyed for a village although were rarely present during the interviews. Households were sampled from six villages across five communes in each of the provinces of Quang Nam and Quang Ninh (Figure 1).

Within each village, the household survey began at the household of the head of the village. Subsequent households were visited by approaching every third household and asking the head of the household if they were prepared to participate in our survey. If the head of the household was not at home another household was selected at random.

Most villages were a network of alleyways/pathways and when a junction was reached, the left or right route was taken alternately.

Survey

Within each household, semi-structured interviews (SSIs) were conducted (Appendix F) to explore i) the role and importance of poultry within the household as a source of both income and food; ii) the precautions taken to protect poultry from diseases, specifically HPAI viruses; iii) the reporting of suspected HPAI H5N1 outbreaks; iv) the response of households to outbreaks of HPAI virus and v) the accuracy of knowledge regarding HPAI H5N1. Only data related to points i) and iv) are discussed in this manuscript. Respondents were typically asked to recall information from no longer than three years previously.

In addition to the SSIs, for every survey household a series of structured closed questions were used to obtain quantitative data on the age and sex of the survey respondents, the number of household occupants and the number and type of poultry (if any) being kept by the household. Data were also collected on the building materials used for the main household dwellings as well as the ownership of luxury goods for use in calculating a household wealth ranking.

As this study involves human participants, ethical approval was received from the University of East Anglia's Research Ethics Committee prior to undertaking this research. All SSIs were conducted in Vietnamese by an interpreter accompanied by a Western researcher with basic Vietnamese language skills who jointly transcribed the responses into English. To preserve respondents' anonymity, information which could identify individual respondents was recorded separately to SSI responses.

Deviations from standard SSIs

Some households were unable to state the percentage contribution poultry made to total household income. In these instances, the respondents were asked if poultry was the main source of income for the household and therefore it was assumed it constituted >50% of total household income.

A small number of households estimated upper and lower limits to the number of animals kept and in these instances the midpoint was taken.

Data Analysis

For each household visited, a wealth ranking was calculated based on the number, size and materials used for the household buildings and the ownership of luxury goods such as motorbikes, dvd players and televisions. The wealth ranking ranged from 0 (very poor) to 3 (relatively wealthy) with increments every 0.5.

The transcribed interviews were entered into a topic-oriented spreadsheet which allowed for the manual coding of interviews, filtering of interview data and the identification of recurring themes. Responses which illustrated similar opinions, behaviours or preferences were sorted into groups based upon shared themes. Triangulation was used to validate responses where necessary (e.g. outbreak dates, number of affected households) through cross-checking the information given against the responses given by other households, local government data (where available), global data or through consultation with key informants from the government DAH.

Mann-Whitney exact U-tests were used to investigate the differences between household size and wealth ranking across the two provinces. Mann-Whitney exact U-tests were also conducted to investigate differences in the number of chickens and ducks kept per household across the two provinces. All statistical tests were carried out using SPSS v16.0.

RESULTS

Sample population

In total 218 households participated in this survey, 114 households within Quang Nam and 104 across Quang Ninh. Households across both provinces have a similar number of household members (mean household size ± SE, Quang Nam 4.8 ± 0.8; Quang Ninh 4.9 ± 0.9, Mann-Whitney U-test, $U = 5552.5$, $p = 0.706$, $n = 214$; Table 2) and wealth rankings (mean wealth ranking ± SE, Quang Nam 2.2 ± 0.4; Quang Ninh 1.9 ± 0.5, Mann-Whitney U-test, $U = 4998.5$, $p = 0.102$, $n = 214$; Table 2).

Table 2 Demographics of the participants in a survey of households within Quang Nam province in central Vietnam and Quang Ninh province in North east Vietnam. All figures are presented as percentages with the exception of those stated as means ± SE.

		Participants by province (%)	
Characteristics		Quang Nam	Quang Ninh
Age (years)	20-29	7.9	3.8
	30-39	34.2	20.2
	40-49	33.3	24.1
	50-59	14.9	26.9
	60-69	7.9	11.5
	70+	1.8	10.6
	Missing data	0	2.9
Respondent(s) gender	Male	42.1	52.9
	Female	53.5	35.6
	Male & Female	4.4	11.5
No. people in household (mean ± SE)		4.8 ± 0.8	4.9 ± 0.9
Household wealth ranking	0.5	1.8	2.9
	1	6.1	7.7
	1.5	18.4	27.8
	2	34.2	28.8
	2.5	17.5	18.3
	3	19.4	13.5
	Missing data	2.6	1
Mean (± SE) wealth ranking		2.2 ± 0.4	1.9 ± 0.5

Respondents in Quang Ninh were generally older than those in Quang Nam; 48.1% of respondents in Quang Ninh were under 50 years of age compared to 75% of Quang Nam respondents (Table 2).

The majority of surveyed households (89%, *n* = 218) kept poultry; either ducks or chickens (Table 3). Six survey households (2.8%, n = 218) kept, in addition to chickens and/or ducks, a total of nineteen geese and as such, the keeping of geese has been excluded from all further analyses. Fewer of the households surveyed in Quang Nam reported vaccinating their poultry against HPAI H5N1 than those in Quang Ninh (Table

3). Only two households (1.9%, *n* = 104), both from Quang Ninh, cited avian influenza as a factor contributing to the decision to stop keeping poultry.

Table 3 Summary of the poultry keeping practices of participants from a survey of households within Quang Nam province in central Vietnam and Quang Ninh province in North east Vietnam.

		Participants by province (%)	
		Quang Nam	Quang Ninh
Poultry	Currently keep poultry	93.9	84.6
	Not currently keeping poultry	2.6	15.4
	Never kept poultry	3.5	0
Number of poultry kept/household	0-10	32.5	48.1
	11-50	49.1	32.7
	51-150	11.4	8.7
	151-500	2.6	9.6
	501+	4.4	1
Household poultry vaccinated?	Yes	78.5	64.8
	No	19.6	30.7
	Not yet	1.9	4.5

Role of poultry in households

Across both provinces, poultry were primarily kept for consumption with the keeping of chickens preferred over the keeping of ducks (Figure 2). Poultry were more commonly kept solely for their meat than for their eggs or a combination of both meat and eggs (Figure 2). Whilst seven households in Quang Ninh kept chickens for cock fighting contests, none of the households in Quang Nam reported keeping any fighting chickens (Figure 2).

The number of ducks kept per household varies significantly between the two provinces (mean ± SE, Quang Nam 48.9 ± 14.8; Quang Ninh 95.8 ± 27.8, Mann-Whitney U-test, U = 5171.0, p=0.049, *n* = 218, Table 2) although the number of chickens kept per household were similar across the two provinces (mean ± SE, Quang Nam 32.1 ± 6.9;

Quang Ninh 34.4 ± 5.7, Mann-Whitney U-test, U = 5120.5, p = 0.126, *n* = 218, Table 2).

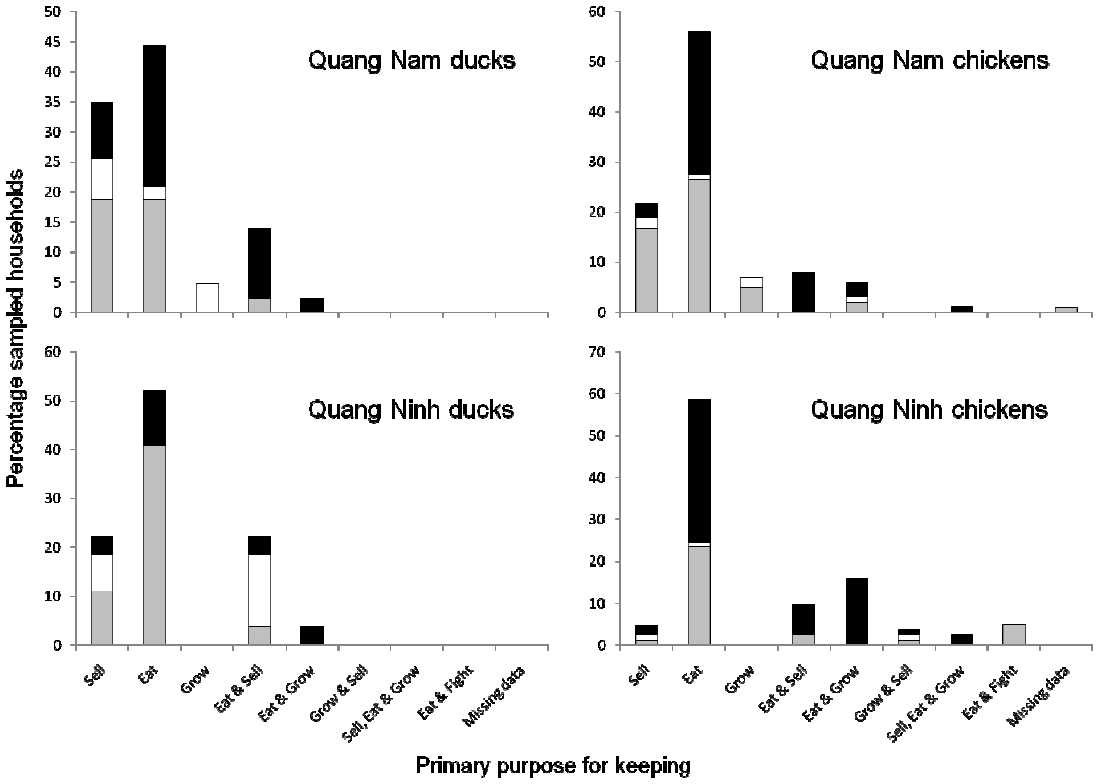

Figure 2 The percentage of households sampled across Quang Nam province (114 households) in central Vietnam and Quang Ninh province (104 households) in North eastern Vietnam keeping ducks and chickens for different livelihood purposes. White bars represent the keeping of eggs, grey represent meat and black bars represent both meat and eggs.

Within Quang Nam, almost every household was involved in poultry production with the majority keeping adult chickens for their meat. Over twice as many households kept chickens compared to ducks and poultry were more commonly kept for their meat than their eggs. Fewer households in Quang Ninh were involved in poultry production but there was still a strong preference for keeping chickens over ducks. Ducks in Quang Ninh were kept primarily for household consumption of the meat whereas chickens were kept primarily for the household consumption of both the meat and eggs. The primary reason for keeping poultry, either ducks or chickens, across both provinces was for household consumption with a stronger preference for this seen in Quang Ninh (Table 3).

Poultry as household income

Quang Nam province

When considering the role of poultry as a source of household income, many respondents (46.7%, *n* = 107) reported that the primary purpose for keeping poultry was for household consumption and as such, poultry make no direct contribution to household income. Few (9.3%, *n* = 107) of the poultry keeping households in Quang Nam reported that ≥50% of household income was derived from poultry. The majority of households (61.7%, *n* =107) earned little or no profit from poultry and reported no change in this during the previous three years.

Estimates given by several households (18.7%, *n* =107), of the percentage of household income derived from poultry resulted in a mean ± SE of 32.8 ± 3.6% with a reported maximum of 80%, seen in just one household. Three (2.8%, *n* =107) further households estimated the amount of money made by their household poultry but were unable to give this as a percentage of the total household income; the amounts reported are 1,000,000VND profit/year (approx. £28 GBP), 50-60,000,000VND/year (approx. £1488-1785 GBP) and approximately 700,000VND/month (approx. £21 GBP).

Quang Ninh province

Poultry provided the main (≥50%) source of household income for few poultry-keeping households (14.8%, *n* =88) with a handful of households (4.5%, *n* =88) reporting ducks as a previous majority income source. For the majority of these poultry-keeping households (70.5%, *n* =88) little or none of their household income comes from poultry, largely because poultry are primarily kept for household consumption. Less poultry-derived profit was currently earned by 14.8% (*n* =88) of households compared to three years ago with a further two households (2.3%) reporting little or no change to the current profit made from poultry compared to three previous years.

Poultry as household food

Quang Nam province

Across both poultry-keeping and non-poultry keeping households, poultry is rarely the most important protein source for consumption. Of the surveyed poultry-keeping households, only four (3.7%, *n* =107) cited poultry as their main household protein

source with four further households (3.7%, *n* =107) citing eggs. Fish (67.5%, *n* =114) followed by pork (10.5%, *n* =114) are the most important protein sources for households surveyed in Quang Nam (Figure 3).

Quang Ninh province

None of the non-poultry keeping households reported poultry or eggs as their primary source of protein for consumption. Of the poultry-keeping households surveyed, only 5.7% (*n* =88) cited eggs as their main protein source with a further 2.3% (*n* =88) reporting chicken or duck meat. As seen in Quang Nam, fish (66.3%, *n* =104) and pork (16.3%, *n* =104) were the most important protein sources for household consumption (Figure 3).

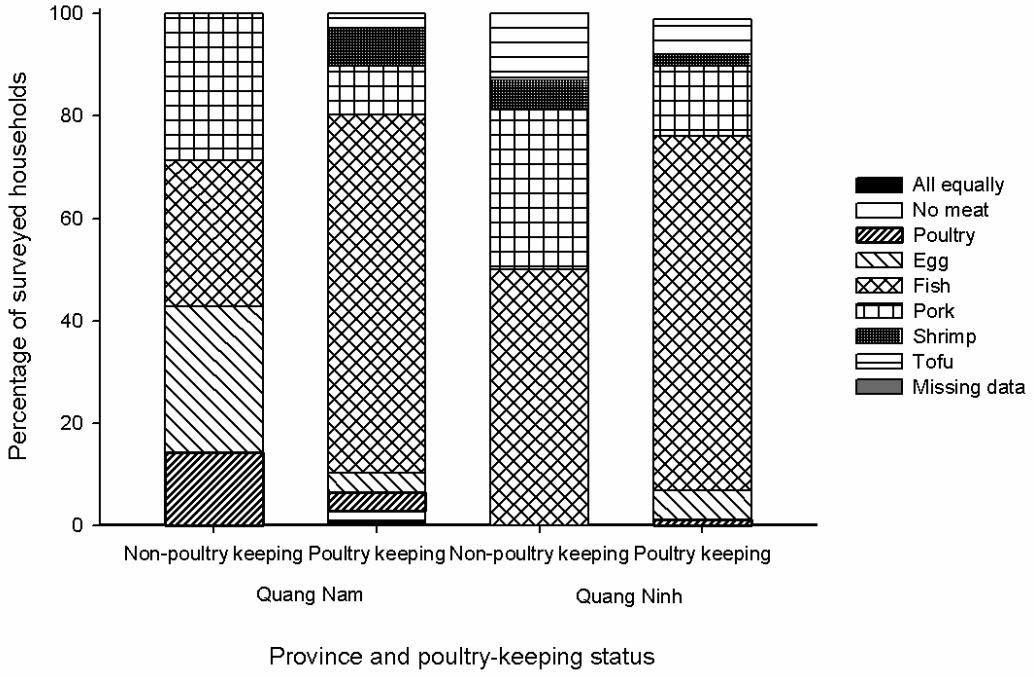

Figure 3 The most important protein source reported by non-poultry-keeping and poultry-keeping households across Quang Nam province in central Vietnam and Quang Ninh province in North east Vietnam.

Whilst more than half (51.8%, n = 195) of all surveyed poultry-keeping households reported poultry to be primarily kept for household consumption, only 14.9% cited poultry or their eggs as their main source of protein. Interestingly, 20.2% of households in Quang Nam (*n* =107) reported only eating and/or keeping poultry for special occasions such as Tet (Vietnamese New Year) as the highest price for chickens is

immediately prior to the Tet celebrations. The importance of poultry for Tet celebrations was emphasised by many respondents:

"...about a month ago about seven chickens died and now I'm worried about the last three. I was trying to raise the birds for Tet." (QNinh, #13)

"I have kept ducks for many years but never for the whole year...sold the ducks last month and will wait to buy ducks to raise for the Tet holiday." (QNam #11)

"I am concerned for the chickens and afraid that if bird flu affects this flock now it might affect Tet holiday and no-one will be to have any money for it [Tet]." (QNam#16)

"I know bird flu is a threat but I still keep some [chickens] for Tet and special occasions." (QNinh #38)

"We only keep about four or five chickens in the house, just for the family to eat on special occasions such as Tet and the anniversaries of the deaths of our ancestors." (QNinh #5)

Reacting to poultry losses

Fewer than one quarter of surveyed households (22.9%, *n* =218) reported disease outbreaks resulting in the loss of part or all their poultry flock through direct mortality or disease control programmes. For the majority of these households (76%, *n* = 50) the disease outbreak which had the most substantial impact on their poultry flock was HPAI H5N1. Following the loss of their birds to HPAI, 2.8% of households (*n* = 214) reported taking on additional financial debt in order to continue keeping poultry. It was not uncommon for respondents to mention the financial burden that HPAI H5N1 had imposed on their households:

"We lost lots of our birds and money [due to bird flu]. We want to keep ducks again but we need to pay off the debt from before first." (QNinh #27)

"...borrowed money from my neighbours and sold my large house to replace the income lost [due to the culling of her poultry flock] and now I live with my daughter and we use wood for fuel instead of electricity." (QNam #61)

"The cost to keep poultry has increased as the food is now manufactured so the price is now higher...the price of selling ducks has declined too...It is very difficult for my family now in the current economy..." (QNinh #1)

"I won't keep lots of chicken again in the future as I can't afford to buy the food." (QNinh #16)

"I want to raise more poultry but money is a problem." (QNinh #22)

Disposal of sick or dead poultry was personally conducted by 11.9% of poultry-keeping households (n = 195) through burial (n = 10), burning (n = 1) or throwing them into a stream (n = 1). Twelve households (6.2%, n = 195) have suffered disease outbreaks resulting in the death of their poultry which was suspected to be HPAI H5N1 but never reported to any authorities.

Table 3 Selected example responses, given during household surveys across Quang Nam province in central Vietnam and Quang Ninh province in North east Vietnam. All respondents were from villages which had suffered outbreaks of highly pathogenic avian influenza strain H5N1 in the preceding 24 months. They were asked i) why they continued to farm poultry and ii) if they were concerned HPAI H5N1 might affect their household in the future.

Persistence with poultry farming/adaptation to disease threats to poultry	*Concern for the future of their poultry flock*
"After bird flu affected the household we stopped keeping poultry for a while. There was no replacement income for the lost ducks and now we have ducks and chickens in the house even though we lost money before." *QNam #13*	"At first everyone was worried as bird flu can be fatal to people but when it came to this commune, I was more worried about the financial damage than human health." *QNinh #27*
"Our household has been in the quarantine zone for bird flu twice before [so their poultry were destroyed]. It took 8 months after the outbreaks to be able to keep poultry again." *QNinh #97*	"20 chickens and 10 ducks died earlier this month...we didn't tell anyone as it wasn't bird flu because no people here got sick." *QNam #32*
"We always keep chickens in this house and we will keep ducks again in the future. Many households here are in debt so they can keep poultry." *QNinh #79*	"In the past about ten fighting chickens died of unknown causes. I was too afraid to eat them so I gave them to other people." *QNinh #5*
"We used to have more poultry but the price is lower now so we keep fewer. We lost money because of this so now we keep a few poultry and spend less money on electricity." *QNam #15*	"There has been no problem of bird flu in this village but cholera [fowl cholera] is a problem." *QNam #60*
	"...not concerned about bird flu returning to this village as I only keep a few chickens. If there are any sick chickens then we eat them or sell them." *QNam #65*

"We are concerned about keeping poultry again [since losing their whole flock two months earlier] but keeping poultry is our lifestyle for so long that we want to do it.....we have borrowed a lot of money to raise these ducks; many households here borrow money for farming even though it has high risk." *QNinh #31*

"Now I keep about half of the poultry I had in the past. I am still concerned about bird flu but poultry is my income and lifestyle and bird flu is an unavoidable threat." *QNinh #31*

Quang Nam province

As a result of HPAI outbreaks affecting their poultry flocks, three households switched their livestock from poultry to keeping fish and shrimp (n = 1) and pigs (n = 2). Nine households reported changes to their diets in recent years with four of these switching due to increases in household wealth. No households in Quang Nam changed their occupation to one other than keeping livestock, appearing instead to prefer to persevere with poultry production.

Quang Ninh province

Of the 28 households directly affected by HPAI H5N1 outbreaks, 39.3% (n = 11) substantially reduced the size of their poultry flock following the outbreaks of the virus with a mean ± SE percentage reduction in the size of poultry flock of 81.8 ± 6.53. A further 10.7% households (n = 3) switched their entire flock of ducks for chickens following outbreaks of HPAI H5N1 and 7.1% (n = 2) ceased keeping poultry for income, opting instead to keep a small flock solely for household consumption. Only 7.1% (n = 2) households reported ceasing poultry keeping altogether as a result of HPAI outbreaks; replacing the income from their culled poultry flocks with employment as freelance labourers. In both instances, these former poultry keepers intended to continue keeping poultry again in the future. Three households affected by HPAI (10.7%, n = 28) reported consuming less poultry following HPAI H5N1 affecting their flock choosing to replace the poultry with pork and fish.

DISCUSSION

Poultry-keeping is undertaken by the majority of households surveyed across the two provinces of Quang Nam in central Vietnam and Quang Ninh in North eastern Vietnam. More than twice as many households keep chickens than ducks and typically, poultry are kept for household consumption rather than as a source of income. At the household level, the most commonly reported impacts of avian influenza outbreaks appear to be short-term indirect effects, typically lasting less than a year, with households choosing to persevere with backyard poultry production rather than switch occupation. Rural Vietnamese poultry producers are persevering with backyard poultry production during a time when the poultry industry is experiencing widespread instability due to factors such as disease outbreaks. The choice to persist with poultry production reflects the mindset of the participants of this study that they are poultry farmers and as such, they will continue to farm poultry despite the risks to their health and livelihoods that this presents. We found that few households seek alternative income sources as a result of disease in their poultry flocks and several households described the financial strain of continuing their traditional lifestyle as poultry farmers and keepers.

Role of poultry in households

Poultry production in Vietnam is a traditional occupation with strong associations to rice cultivation. Joint crop and animal production, especially poultry, are common components of the mixed farming systems of rural Vietnam, forming an integral part of village life with important social functions (Hong Hanh *et al.* 2007). Poultry forms a relatively small but important source of food and income for poor households in Vietnam (Epprecht *et al.* 2007) where household poultry production typically consists of flocks of fewer than 50 birds (Hong Hanh *et al.* 2007). The diet for these backyard flocks largely comes from free-range scavenging supplemented by kitchen waste and home-grown grains, typically rice (Hong Hanh *et al.* 2007). This form of backyard poultry production is estimated to contribute approx. 5%, of Vietnam's GDP with the majority of these poultry producers coming from poor rural households (Otte *et al.* 2006).

The raising of poultry, primarily for consumption, by the majority of those surveyed highlights the important role that poultry plays within rural households and the ease

with which these families can become involved in poultry raising. The preference found in our study for keeping chickens over ducks, particularly in Quang Ninh, confirms previous studies which have found chickens to outnumber ducks and geese in the Red River delta and the converse to be the case in the Mekong River delta (FAO 2007; Hong Hanh *et al.* 2007) and we attribute this bias to be due to the low initial investment, cheap food costs, short production cycle, small space required and general ease of keeping chickens.

Poultry as a source of household income and food

The low input and investment needed to keep backyard poultry makes it accessible to all income strata; approximately 50% of Vietnam's lowest two income quintiles participate in backyard poultry raising compared to slightly over 20% of the richest quintile (Burgos *et al.* 2008). This same study also found that backyard poultry rarely contributes more than 30% of total household income, a finding supported by our research which found few households reporting poultry to be a main source of income.

The low income potential for poultry observed in the survey communities emphasises the ease and low input required to keep poultry. It suggests that the role of backyard poultry flocks within rural Vietnamese communities is rather as an asset that can be kept easily for future sale or consumption, likely in support of an important festival or family occasion, to match the needs of the household.

Disturbances to poultry production systems, such as outbreaks of HPAI H5N1 and the subsequent control efforts have resulted in the loss of entire household poultry flocks; effectively removing the opportunity for household poultry consumption (Sonaiya 2007). These actions impact upon livelihoods through decreased food security and household income for rural poultry producers and can have knock-on effects throughout the food production system. Food systems experiencing stress can prompt households to take unusual and risky actions such as the consumption of birds which may have died of HPAI H5N1 or other infectious diseases (Sonaiya 2007) and the hiding of suspected HPAI virus outbreaks. The absence of alternative protein and income sources can leave households vulnerable and facing difficult economic decisions.

Food security is considered to be the physical and financial access to sufficient food to meet a person's dietary needs and food preferences (WFS 1996). The keeping of backyard poultry flocks may result in households consuming home-grown poultry rather than purchasing food for consumption, however this was not seen in our study. The households surveyed here primarily kept backyard poultry for household consumption, but poultry rarely constituted one of the main household protein sources. During the festivals which take place for Vietnamese New Year, known as Tet, chickens are brought into households for slaughter and consumption during a traditional ceremony (Williams 2005; Martin *et al.* 2006). The increased poultry production associated with this time of year has been linked to the first and second HPAI H5N1 epizootic waves across Vietnam (FAO 2007). The importance put upon poultry as a food source for special occasions rather than for daily consumption leads us to conclude that shocks to Vietnam's backyard poultry production systems are unlikely to result in food shortages for rural households affected by HPAI H5N1 outbreaks.

Reacting to poultry losses

Disease outbreaks have resulted in the death of large numbers of household poultry for almost one quarter of the households surveyed in this study; the majority of these households report HPAI H5N1 as the most serious disease threat to their flocks. Rapid and unexpected shocks to the livestock sector are likely to have the most significant impact on small-scale household producers as these households may lack the resources to recover and diversify their livelihoods (UNDP 2006). Relatively few of the surveyed households altered their diet or livelihood activities as a result of HPAI outbreaks in their poultry flocks. Replacing the income lost from poultry with alternative livestock, the borrowing of money from banks and family members to purchase more poultry and the switching of occupation were all undertaken by a minority of survey participants with the majority of those affected by HPAI opting to persist with household poultry production.

Disease outbreaks in livestock can introduce local or national economic instability with fluctuation in both demand and supply resulting in price instability. Research has shown that following the confirmation of HPAI outbreaks in Nigeria, the public responded initially with panic, followed by a total boycott of poultry and poultry products (UNDP

2006). In the fortnight following the initial HPAI outbreaks, sales of chickens and eggs declined by 80% and four months later, prices were still less than 50% of those seen pre-HPAI (UNDP 2006).

Persevering with poultry

Poultry-farming exposes household members to health risks. Human infection with HPAI H5N1 virus is known to be associated with recent exposure to live poultry (Mounts *et al.* 1999) direct contact with dead poultry (Areechokchai *et al.* 2006) and the preparation or cooking of unhealthy, sick or dead poultry (Beigel *et al.* 2005, Dinh *et al.* 2006). Poultry farming has also been shown to present transmission risks for other human pathogens such as *Salmonella* and *Campylobacter jejuni* (Bryan & Doyle 1995). In addition to direct health threats, rural backyard poultry producers may feel livelihood impacts from outbreaks of diseases such as HPAI through mechanisms including the loss of income from poultry sales; the devaluation of poultry; reduced poultry productivity and a reduction in household food security (Birol 2008).

The risks and insecurities for household economies and health presented by participating in poultry production lead us to ask the question, why are households persevering with backyard poultry production?

Previous research has highlighted the ability of the rural poor to cope with adaptation, innovation and livelihood diversification in the face of changes to their environment (Scherr 2000; Marshall and Marshall 2007). Whilst wealthier households might be able to buffer unexpected livelihood shocks through e.g. the use of financial capital such as cash savings, households of the rural poor involved in backyard poultry production may find their physical capital in the form of livestock, lost through outbreaks of diseases such as HPAI. A recent study within Northern Vietnam found that 25% of rural households reported the death of their livestock as a shock to their household, the most commonly reported problem experienced by the 203 households surveyed (Fischer 2010).

We have found that Vietnamese poultry farmers exhibit a strong attachment for maintaining a livelihood centred around poultry farming. This strong attachment

manifests itself as resistance to livelihood changes and diversification despite the livelihood shocks resulting from disease outbreaks in their poultry flocks. Such behaviour fits within the term of social resilience, whereby communities demonstrate an ability to tolerate external stresses such as unstable economies and disease outbreaks, whilst maintaining a sustainable livelihood (Adger 2000). Attempts to demonstrate such resilience has also been seen for those whose occupation is dependent on natural resources, particularly in marine ecosystems, although in many cases the rate of environmental change is greater than the resilience of these communities (e.g. Marshall & Marshall 2007; Forster 2010). Typically it would be expected that for households with a livelihood under stress, such as through environmental change or economic instability, that the household members would seek to pursue livelihood diversification (Ellis 2000). Such livelihood diversification has not been seen in our study where we have found that rural Vietnamese for whom poultry farming is an occupation, choose to persist with keeping poultry despite facing livelihood risks. This persistence may be attributed to i) a lack of resources, in this context most likely financial, physical or social resulting in a reluctance to move away from a familiar livelihood, ii) a lack of knowledge regarding the alternative livelihoods available, iii) poor access, either physically, financially or intellectually to an alternative livelihood or a support network for livelihood diversification and iv) reluctance to diversify/shift livelihood due to the long-held tradition and culture of poultry-keeping within a household or community.

Within the realm of this study, continued participation in backyard poultry production is likely to be due to a range of factors, discussed throughout this manuscript, including the low-investment required, high potential return, the simplicity of keeping poultry birds in terms of time, space, attention and low maintenance costs and poultry farming being embedded into the culture of many rural Vietnamese households. The ease with which households can partake in poultry production combined with the traditional nature of this practice and the difficulties rural Vietnamese households face in switching occupation, results in backyard poultry farmers facing a difficult choice; to continue with poultry production at the risk of disease outbreaks, unstable markets and additional debt or switch occupation and adapt their livelihoods to enter a new world of unknown risks. Our study has found that rural Vietnamese poultry farmers show resilience to

disruption to their poultry production systems and choose to persevere with their poultry flocks.

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Chapter 6

Protecting poultry, reporting outbreaks and knowledge of HPAI H5N1 outbreaks in rural Vietnam.

Live ducks being taken to market in Quang Nam province. Photo by Kelly Edmunds.

ABSTRACT

Highly pathogenic avian influenza (HPAI) strain H5N1 has had significant impact across Asia, Africa and Europe, causing particular devastation to human and poultry populations within Egypt, Indonesia, Thailand and Vietnam. A variety of methods have been employed in the effort to control the spread of HPAI H5N1 and these efforts to control HPAI H5N1 have been most marked within Southeast Asia, where the highest numbers of human and poultry cases have been reported. The success of HPAI H5N1 control programmes depend on accurate surveillance and reporting of outbreaks as well as the participation and cooperation of poultry farmers, particularly backyard poultry farmers, for whom the free-ranging of flocks is standard practice.

We conducted a survey of 218 rural households across two provinces within Vietnam to explore the attitudes and practices involved in protecting household poultry flocks as well as knowledge of HPAI H5N1. We found that over one quarter of households lacked up-to-date vaccinations for their poultry and that the administering of preventative measures formulated by the farmers themselves was a common practice. Despite poultry being kept by 89% of the survey respondents, more than 30% of respondents were unaware that HPAI H5N1 outbreaks had taken place in their village.

We also compared local reports of HPAI H5N1 outbreaks with those reported to a global database and found massive under-reporting to the latter. We consider the implications of under-reporting these disease outbreaks for epidemiological studies and HPAI surveillance and control programmes. Finally we suggest that additional investment in local veterinary services may improve HPAI H5N1 outbreak reporting, knowledge communication and overall veterinary facilities within rural poultry-farming communities.

INTRODUCTION

Highly pathogenic avian influenza (HPAI) strain H5N1 resurfaced in Southeast Asia in 2003 and has since devastated the poultry industry across large parts of the region (Olsen *et al.* 2006; Thorson *et al.* 2006; Hong Hanh *et al.* 2007). Due to these impacts, the fight to control HPAI H5N1 has been most evident within Southeast Asia, where the highest numbers of human and poultry cases have been reported. Within Vietnam alone, more than 50 million poultry birds are estimated to have died or been destroyed as a result of HPAI H5N1 outbreaks (Sims & Dung 2009). HPAI strain H5N1 was endemic in Vietnam prior to the start of the vaccination campaign (Sims & Dung 2009) and continues to pose a threat across the country with seven human cases in 2010 (WHO 2011) and, as at 16/05/011, 25 reported poultry cases during 2011 (OIE 2011).

Measures for controlling outbreaks of HPAI H5N1 vary between countries with some, such as Thailand, Nigeria and Japan, employing a strategy of stamping out infected flocks combined with other measures such as enhanced biosecurity and farm surveillance whereas Hong Kong, Egypt and Indonesia opt to employ widespread vaccination campaigns in their efforts to control the spread of the virus (FAO 2007; FAO 2011). Initially Vietnam followed the stamping out measures employed by the majority of other countries affected by HPAI H5N1 (Domenech *et al.* 2009). Yet in 2005, as the number of reported human cases in Vietnam continued to increase, Vietnamese authorities chose to change their strategy and in 2006 deployed a nationwide vaccination campaign (Domenech *et al.* 2009).

In response to the severity of early outbreaks of HPAI H5N1 and concern for a potential global pandemic, numerous avian influenza surveillance programmes were established, including the Wildlife Conservation Society's Global Avian Influenza Network Surveillance (GAINS); the Highly Pathogenic Avian Influenza Early Detection Data System (HEDDS); the Emergency Prevention System for Priority Animal and Plant Pests and Diseases (EMPRES-i) of the Food and Agricultural Organisation of the United Nations (FAO) and the World Organisation for Animal Health's (OIE) World Animal Health Information Database. In addition, governments from several of the

countries most severely affected by HPAI have set up wild bird surveillance programmes as part of these global surveillance programmes.

Surveillance and reporting strategies vary between countries in their employment, accuracy and effectiveness (FAO 2011). Recent studies have unveiled discrepancies in the completeness of global HPAI outbreak datasets (e.g. Farnsworth *et al.* 2010; Zhang *et al.* 2010) with differences being found in both the temporal and spatial distribution of recorded outbreaks, leading to the recommendation of development of an integrated dataset (Zhang *et al.* 2010). Within-country reporting varies between administrative sectors with differences seen in the outbreaks reported at Vietnam's provincial level and the number of outbreaks reported as far as central government (FAO 2011). Determining the extent to which rural Vietnam's locally-reported HPAI H5N1 outbreaks are under-reported to the global surveillance databases will assist our understanding of the impacts which these disease outbreaks are likely to have within Vietnam's poultry producing communities.

Recently it has been suggested that backyard poultry farmers are reluctant to engage in simple biosecurity measures, even when HPAI H5N1 presents a clear and serious threat to their poultry flock (FAO 2011). This reluctance to undertake preventative measures may result from poor, inaccurate knowledge of the virus itself and associated transmission and outbreak risks or farmers believing that the benefits of poultry farming outweigh the potential costs to their livelihoods.

This paper investigates the measures taken by Vietnamese rural poultry keepers to protect poultry from diseases, particularly HPAI H5N1. We also compare local reports of potential HPAI virus outbreaks from two localities with the outbreaks reported to a global database of confirmed reports of HPAI H5N1 outbreaks. Finally we examine the awareness and accuracy of knowledge held by rural Vietnamese communities, regarding HPAI H5N1.

METHODOLOGY

Sampling

This study focuses on rural households within the provinces of Quang Nam and Quang Ninh (Figure 1). Within these two provinces, communes which had reported outbreaks of HPAI H5N1 in the previous three years were visited, the provincial People's Committees approached and permission obtained for conducting our research. With the help of officials from local Departments of Animal Health (DAH), villages experiencing HPAI H5N1 outbreaks in the previous three years were visited and a household survey conducted.

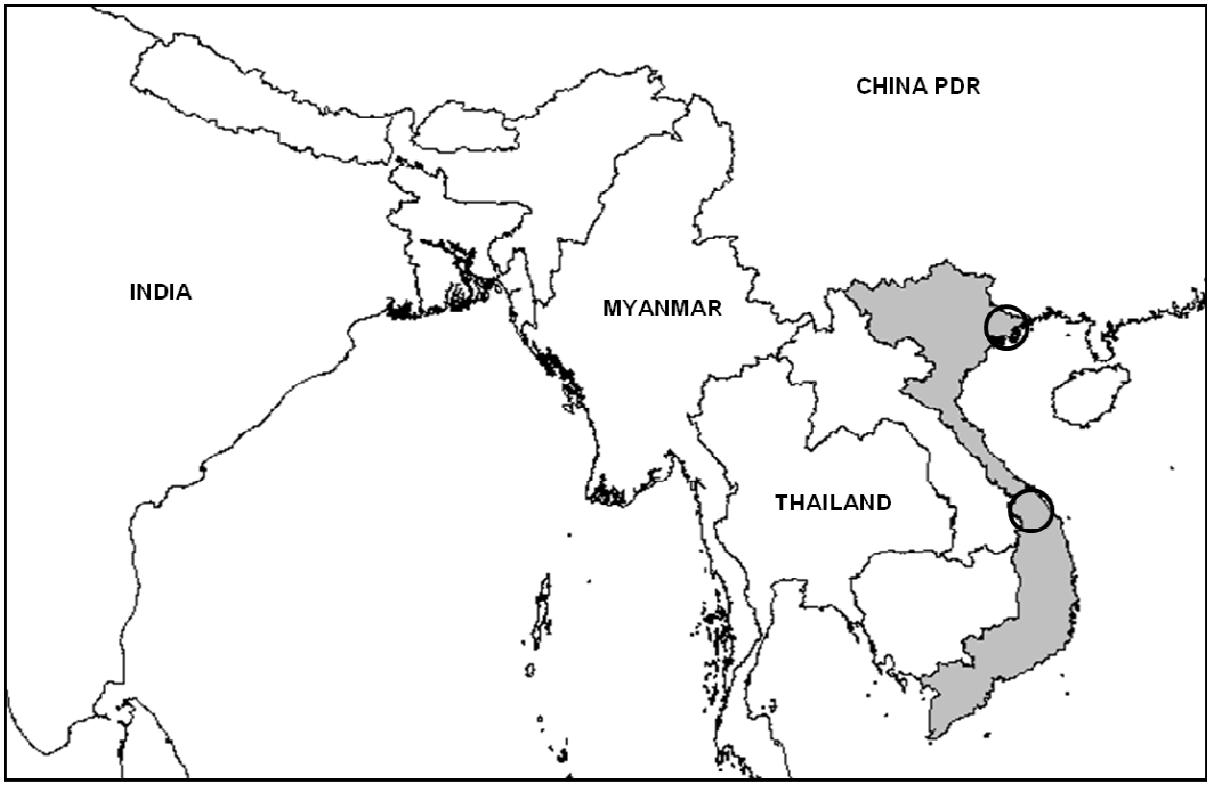

Figure 1 Map showing the location of Vietnam (shaded) within Southeast Asia and the provinces of Quang Ninh (northernmost) and Quang Nam. Five communes within each province were sampled during a household survey investigating the impacts of highly pathogenic avian influenza on rural poultry-keeping communities.

Table 1 Demographic and topographic status of the two provinces within Vietnam in which household surveys were conducted to explore the impacts of HPAI H5N1 virus on rural livelihoods and poultry production. Unless otherwise stated, all figures come from the General Statistics Office of Vietnam, 2009.

	Quang Nam	**Quang Ninh**
Area (km^2)	6,099	10,438.4
Human population density	136	188
No. poultry (at end 2008)	3,410,000	2,113,000
Poultry density ($/km^2$)	559	202
Province location	Central Vietnam	Red River Delta/ Northeast Vietnam
Topography	Coastal lowlands in the east through to montane in the west	Mostly river delta and coastal lowlands
Provincial borders	Borders Lao PDR to the west and the Gulf of Tonkin to the east.	Borders China PDR to the north/northeast and the Gulf of Tonkin to the east/southwest
No. HPAI H5N1 poultry outbreaks[1]	39 (including 1 post-survey)	56 (including 3 post-survey)
No. poultry dead/destroyed due to HPAI H5N1[1]	>29,519	>52,225

[1-] As reported to the World Organisation for Animal Health as at 18/05/11 (OIE 2011).

During surveys within Quang Nam in November 2008 and Quang Ninh in January 2010, the local DAH officials provided information regarding the impacts of HPAI H5N1 in the villages as well as a tour which included an introduction to the head of each village. Typically the DAH official(s) would accompany the household survey for the first morning of surveys before leaving; occasionally they accompanied visits to all households surveyed for a village although were rarely present during the interviews. Households were sampled from six villages across five communes in each of the provinces of Quang Nam and Quang Ninh (Figure 1).

Within each village, the household survey began at the household of the head of the village. Subsequent households were visited by approaching every third household and asking the head of the household if they were prepared to participate in our survey. If

the head of the household was not at home another household was selected at random. Most villages were a network of alleyways/pathways and when a junction was reached, the left or right route was taken alternately.

Survey

Within each household, semi-structured interviews (SSIs) were conducted (Appendix F) to explore i) the role and importance of poultry within the household as a source of both income and food; ii) the precautions taken to protect poultry from diseases, specifically HPAI viruses; iii) the reporting of suspected HPAI H5N1 outbreaks; iv) the response of households to outbreaks of HPAI virus and v) the accuracy of knowledge regarding HPAI H5N1. Only data related to points ii), iii) and v) are discussed in this manuscript. Respondents were typically asked to recall information from no longer than three years previously.

In addition to the SSIs, for every survey household a series of structured closed questions were used to obtain quantitative data on the age and sex of the survey respondents, the number of household occupants and the number and type of poultry (if any) being kept by the household. Data were also collected on the building materials used for the main household dwellings as well as the ownership of luxury goods for use in calculating a household wealth ranking.

As this study involves human participants, ethical approval was received from the University of East Anglia's Research Ethics Committee prior to undertaking this research. All SSIs were conducted in Vietnamese by an interpreter accompanied by a Western researcher with basic Vietnamese language skills who jointly transcribed the responses into English. To preserve respondents' anonymity, information which could identify individual respondents was recorded separately to SSI responses.

Deviations from standard SSIs

Some households were unable to state the percentage contribution poultry made to total household income. In these instances, the respondents were asked if poultry was the

main source of income for the household and therefore it was assumed it constituted >50% of total household income.

A small number of households estimated upper and lower limits to the number of animals kept and in these instances the midpoint was taken.

Data Analysis

For each household visited, a wealth ranking was calculated based on the number, size and materials used for the household buildings and the ownership of luxury goods such as motorbikes, dvd players and televisions. The wealth ranking ranged from 0 (very poor) to 3 (relatively wealthy) with increments every 0.5.

The transcribed interviews were entered into a topic-oriented spreadsheet which allowed for the manual coding of interviews, filtering of interview data and the identification of recurring themes. Responses which illustrated similar opinions, behaviours or preferences were sorted into groups based upon shared themes. Triangulation was used to validate responses where necessary (e.g. outbreak dates, number of affected households) through cross-checking the information given against the responses given by other households, local government data (where available), global data or through consultation with key informants from the government DAH.

RESULTS

In total 218 households participated in this survey, 114 households within Quang Nam and 104 across Quang Ninh. As reported in chapter 4, households across both provinces have a similar number of household members (see chapter 4). Of the 218 households surveyed across both Quang Nam and Quang Ninh, the majority (89%) currently keep poultry. The number of ducks kept per household varies significantly between the two provinces (see chapter 4).However, the number of chickens kept per household does not vary significantly between the two provinces (see chapter 4).

Protecting poultry

Two-thirds of the poultry-keeping households surveyed (67.2%, *n* = 195) were concerned that HPAI H5N1 may affect their household in the future. Of these households, 64% (*n* = 81) were from Quang Nam and 36% (*n* = 47) in Quang Ninh. A small number of the non-poultry keeping households (26.1%, *n* = 23) were also concerned that HPAI H5N1 may affect their households in the future. Despite this concern for HPAI H5N1, few of the poultry-keeping households surveyed (8.7%, *n* = 195) make any attempt to separate their poultry from other flocks within their village or from other species of poultry.

Vaccinations

Within Quang Nam, a number of (21.5%, *n* = 107) of the poultry-keeping households had not vaccinated their current poultry against HPAI H5N1. Up-to-date HPAI vaccination appeared to be less common in Quang Ninh, with almost one third (31.8%, *n* = 88) of poultry-keeping households lacking up-to-date vaccinations for their poultry; four households declined to answer the question (Table 2).

Attitudes to vaccinating poultry against HPAI H5N1 varied between the households, with most households vaccinating their birds if it was convenient rather than considering their vaccination to be a priority. When asked about protecting their poultry from HPAI H5N1 through vaccinations, examples of the respondent's replies were as follows:

"My birds are vaccinated. Only the chickens though, I don't care about vaccinating the ducks." QNinh #67

"The chickens are kept in an airy and fresh environment and as they have been kept for several years, there's no need to vaccinate them." QNinh #23

"The poultry are not vaccinated as we only keep a few and we were not at home when they came to vaccinate." QNinh #5

"The chickens are not vaccinated as there have been no bird flu outbreaks in the village this year." QNam #77

"I don't think the Department of Animal Health have done any vaccinating this year so my poultry are not vaccinated." QNam #82

The HPAI H5N1 vaccination strategy employed by the local-level DAH varied between communes. All except one commune employed a door-to-door poultry vaccination strategy, with the final commune utilising a central location (also used as the outdoor food market) for vaccinations, with poultry from the neighbouring villages all being taken to this one site to have the vaccines administered. One official involved in organising the door-to-door approach informed us that if poultry owners were not at home when they go to administer the vaccines, the household misses out on the vaccinations and the poultry go unvaccinated for that round.

Alternative medicine

In Quang Nam, more than half of the surveyed households (57.5%, n = 106) chose not to use non-vaccine treatments to protect their poultry against diseases such as HPAI H5N1. Of the 45 households (42.5%) who reported providing their poultry with medicine, five use unconventional treatments; two households mix calcium carbonate with the food and/or water given to the birds, two households mix snake wine and garlic with rice to feed to their chickens and the fifth house did not specify which type of "simple medicine" they use (Table 2). The remaining 40 households typically buy medicinal products from the DAH (72.5%) with five households (12.5%) buying their medicine from the markets and six households (15%) not disclosing or not knowing the source for their medicines.

Substantially fewer poultry-keeping households in Quang Ninh (9.1%, n = 88) provided no medicine for their poultry or hygiene practices for its environment. More than half of the households (54%, n = 88) were unable/refused to specify which medication they administer to their poultry or the actions they take to clean their poultry's environment. Of the 32 households (36.8%) which did provide details; 21 sprayed antiseptic

chemicals supplied by the DAH around their poultry-keeping areas, six households spread calcium carbonate around the poultry-keeping environment, three households mix medicine in with the poultry food/water and two households give their poultry unspecified “medicine and injections”

Table 2 The number of households which provide their poultry with vaccinations and/or medicine as a means of preventing HPAI H5N1. Sample quotes regarding the provision of non-vaccine medicine are also given. All data derived from surveys across Quang Nam province in central Vietnam and Quang Ninh province in North east Vietnam. DAH – Department of Animal Health.

	Households keeping poultry	**Households who vaccinate poultry (%)**	**Poultry given medicine?**			**User of alternative medicine?**	**Where medicine purchased from?**		
			Yes	No	No answer		DAH	Local market	Source unspecified
Quang Nam	107 (93.9%)	84 (78.5%)	41(38.3%)	60 (56.1%)	6 (5.6%)	5	29	5	7
Quang Ninh	88 (84.6%)	56 (63.6%)	71 (80.7%)	17 (19.3%)	0	1	7	1	63

"I give medicine to boost their immune system, antiseptic chemicals and calcium carbonate for the environment." QNinh #65

"I use snake wine to mix with rice and garlic and give it to the chickens." QNam #88

"I don't use medicine but I give wine and garlic in with the rice for the chickens." QNam #90

"I mix calcium carbonate with water and rice for the chickens." QNam #106

"I use garlic in the duck food and calcium carbonate to treat the environment." QNam #16

Reporting suspected HPAI H5N1 outbreaks

Quang Nam

Data for the period February-May 2008 obtained for just one of the districts visited during our surveys reported 2,606 birds dying in 31 confirmed HPAI H5N1 outbreaks. A further 11,443 birds were also reported as being destroyed due to the procedures in place to control outbreaks (Figure 2). Of these 31 reportedly confirmed HPAI H5N1 outbreaks, only five (16.1%) appear within the OIE database for Vietnam's HPAI H5N1 outbreaks. The five outbreaks reported to OIE give a total of 419 birds which died due to HPAI H5N1 with a further 2,277 destroyed during the control programme (Figure 2). It is unclear which of the reporting procedures in place were responsible for 26 HPAI H5N1 outbreaks being reported to the local government but not then being passed on as far as the OIE and therefore, the international community. These 26 unreported outbreaks occurred over a four month period in just one district from one of Vietnam's 63 provinces and city municipalities. During this same time period, the OIE was notified of eight HPAI H5N1 outbreaks occurring across the whole of Quang Nam province, resulting in 797 dead birds with a further 2770 birds destroyed to control virus spread (Figure 2).

According to respondents from Quang Nam, HPAI H5N1 outbreaks have affected poultry from almost one in five households (17.8%, n = 107). These households claim to have lost more than 2,400 birds due to suspected HPAI H5N1 outbreaks with an additional 2,820 birds reportedly destroyed in these villages as a direct result of HPAI H5N1 control. Of these reportedly affected households, 13 (68.4%) did not receive compensation but of these, three (15.8%) did not officially report their poultry deaths. A further five households (26.3%) received some compensation with one (5.3%) household still awaiting their compensation.

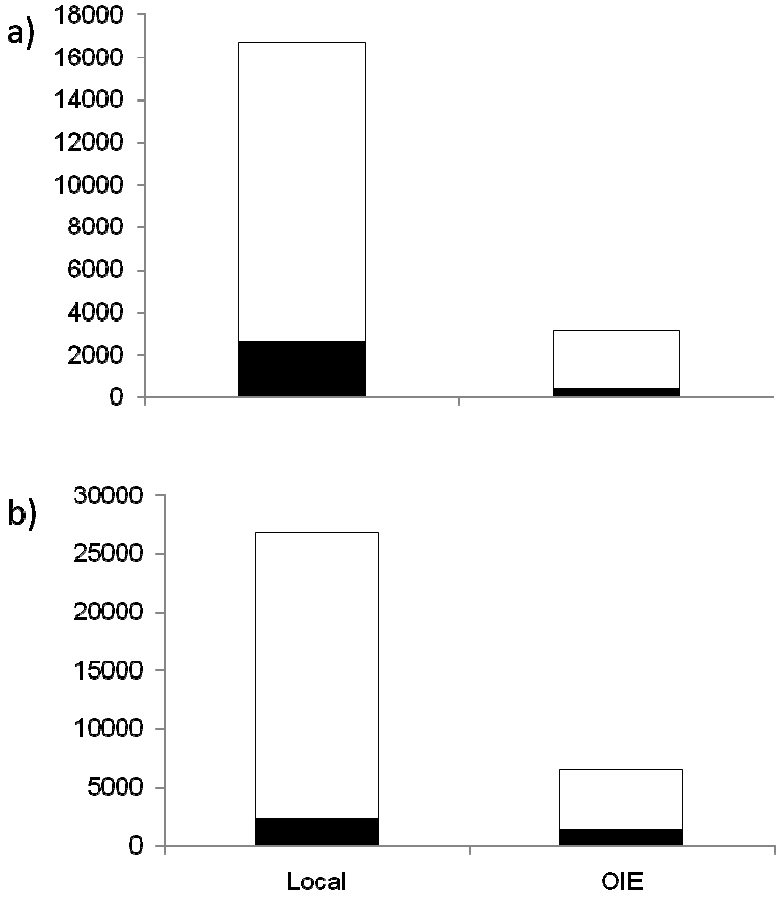

Figure 2 The disparity between the number of poultry reported dead due to highly pathogenic avian influenza (HPAI) strain H5N1 in local government reports and to the international database of the World Organisation for Animal Health (OIE). Data are taken from a sample of districts surveyed within a) Quang Nam and b) Quang Ninh, Vietnam in 2008-2010. Black bars represent reported poultry deaths due to HPAI H5N1 infection and white bars represent the total number of poultry reported dead due to HPAI H5N1 infection and control programmes.

Quang Ninh

Data on confirmed HPAI H5N1 outbreaks were obtained for the whole province from 2004 through to mid-2009. These data report 308,143 poultry being destroyed across six districts of Quang Ninh in 17 separate clusters of HPAI H5N1 outbreaks. The majority of these poultry deaths were reported during 2005 when 278,533 (90.4%) poultry died and were destroyed across three districts. Over the same time period, reports to the OIE give details of 44,771 poultry having died due to HPAI H5N1 infection and control (Figure 2), 14.5% of the locally reported total, within Quang Ninh across approximately 15 separate outbreak clusters.

During the three years preceding our surveys, local official reports from the three surveyed districts claim 2,322 poultry died due to HPAI H5N1 infection and 22,125 poultry birds were destroyed due to HPAI H5N1 control (Figure 2). Over the same time period, the OIE database has records of a total of 3,753 birds dead due to HPAI infection and control (1,354 as a result of infection and 2,399 due to control efforts).

Almost one-third of the poultry households surveyed in Quang Ninh (31.8%, n = 88) believed they may have had HPAI H5N1 outbreaks in their poultry flocks. In total these households claim to have lost more than 4,400 birds as a result of suspected HPAI H5N1 outbreaks with an additional minimum of 6,065 birds destroyed as a result of HPAI H5N1 control. Of these affected households, four (14.3%, n = 28) did not receive compensation but of these, two did not officially report their poultry deaths. A further twenty households (71.4%) received some level of compensation with one household still awaiting their compensation.

Knowledge of HPAI H5N1 outbreaks

Half (50.9%, n = 210) of responding households were aware that HPAI H5N1 affects countries across the world and is not specific to Vietnam. The majority of the remaining households (20.5%, n = 210) believed HPAI H5N1 only affects Asian countries and almost all of these households (93.0%, n = 43) believed it is a problem specific to Vietnam. Households who were unaware of the scale at which H5N1 was a problem made up 16.2% (n = 210) of the surveyed households, followed by 26 households (12.4%, n = 210) which believed HPAI H5N1 is restricted to their commune or village.

Approximately one third of all surveyed households (32.6%, n = 210) were not aware of any HPAI H5N1 outbreaks having occurred in their village. A small majority of households (39.9%, n = 210) were aware of HPAI H5N1 having reached their village but none of the respondents could correctly state how many outbreaks had occurred in their village. The remaining 60 (27.5%) households were unaware of whether HPAI H5N1 had reached their village or chose not to answer the question.

DISCUSSION

Despite the recent and recurrent outbreaks of HPAI H5N1 within our survey villages, we found inadequate and varying levels of protection for poultry against HPAI H5N1 as well as varied knowledge and reporting of such outbreaks. We found that over one quarter of all responding households lacked up-to-date vaccinations for their poultry with many households, particularly in Quang Ninh, providing alternative veterinary treatment for their poultry as well as attempting to provide a clean environment for their birds. Whilst HPAI H5N1 outbreaks are notifiable to the OIE, only a small proportion of locally confirmed outbreaks appear to be reported to the OIE's global database (16.1% of outbreaks in Quang Nam and 14.5% of birds dead due to HPAI H5N1 infection and control in Quang Ninh). Half of all respondents are unaware of the global extent of HPAI H5N1 outbreaks and despite outbreaks having occurred in all of our survey villages, approximately one third of respondents were not aware of HPAI H5N1 having affected their village.

Protecting poultry

Veterinary support for backyard poultry farmers comes from veterinarians employed by the government DAH but operating at the commune level and supervised by veterinarians at the district and provincial level. In the effort to control the spread of HPAI H5N1, several actions were taken within Vietnam, many of which were directed by the National Committee for Avian Influenza Disease Control and Prevention, a committee set up in January 2004 to coordinate and oversee the strategic planning of Vietnam's HPAI control programme (Burgos *et al.* 2008).

The measures put in place to combat HPAI H5N1 outbreaks ranged from a nationwide poultry vaccination programme, large-scale culling and the closure of poultry markets to the introduction of legislation (Burgos *et al.* 2008; Yee *et al.* 2009). Legislation (decree 69/2005/TT-BNN) introduced in 2005 to control the spread of HPAI H5N1 includes bans on buying and selling infected poultry, hiding suspected outbreaks, the sale of poultry from an infected area within 21 days of an outbreak and the free-ranging of chickens and ducks, particularly ducks living in open water.

Despite the government introducing numerous measures aimed at controlling HPAI H5N1 outbreaks, this research suggests that participation remains largely voluntary and as a result, backyard poultry rearing in Vietnam typically takes place with minimal biosecurity measures in place; poultry are left to free-range in the land and ponds surrounding households, mixing with flocks from the neighbouring households (Sims & Dung 2009). Our surveys found slightly over two thirds of poultry-keeping households to be concerned about HPAI H5N1 affecting their flocks in the future with more concern apparent in the households within the central province of Quang Nam. Despite this stated concern for the health of their poultry flocks, over one fifth of households in Quang Nam and over one third of households within Quang Ninh did not have up-to-date HPAI H5N1 vaccinations for their poultry.

A variety of vaccination strategies were reported for the survey communes. The scale of these vaccination campaigns necessitated the combined involvement of DAH veterinarians and local people, many of whom have little or no veterinary training. The majority of communes surveyed employ a door-to-door vaccination policy where the vaccination team visit all households known to keep poultry and administer the vaccine injections. One commune was found to employ a different vaccination strategy, choosing to opt for a communal vaccination centre which farmers bring their poultry to in order to get the birds vaccinated. Each of these approaches encounters problems. The door-to-door strategy relies on the poultry-keeping households reporting that they keep poultry and also someone being at home when the vaccination team visit; notice may or may not be given in advance of the vaccination round. The communal vaccination strategy relies on the farmers bringing their poultry to the communal vaccination centre on the allotted vaccination day. From a disease transmission perspective this latter approach is also concerning as it promotes the mixing of poultry from across several villages thereby introducing the potential for pathogen transmission. With vaccination rounds taking place every six months, a poultry flock which skips a vaccination session may be vulnerable to HPAI infection, leading to negative consequences for their household and those within the surrounding quarantine zone.

At the household level, in addition to participating in government vaccination campaigns, a third of households in Quang Nam and the majority of households in Quang Ninh, administer medicine to their poultry ranging from medicine bought from government veterinary pharmacies to that bought at the local markets and owner-prescribed alternative medicines such rice wine or garlic mixed in with poultry food. Whilst the health properties of garlic are widely known (e.g. Wynn and Fougère 2007), scientific evidence regarding the use of garlic or rice wine to combat HPAI H5N1 in chickens is currently lacking.

Reporting suspected HPAI H5N1 outbreaks

HPAI H5N1 is classed by the OIE as a notifiable disease and as a result, all outbreaks of H5 and H7 strain avian influenza viruses in member countries (Vietnam is one of the 174 of these) should be reported to the OIE. The OIE is then able to circulate the relevant details to the wider global community who can take appropriate surveillance/preventative/responsive actions where necessary. However, countries in which HPAI H5N1 maintains an endemic status are not obliged to report details of all outbreaks provided they have their own in-country system for reporting and recording outbreaks.

A recent study comparing national and global HPAI H5N1 reporting systems found discrepancies between the number of outbreaks reported locally and those reaching national databases, with more outbreaks being reported locally (Farnsworth *et al.* 2010). Our study also found substantial disparity between the number of poultry deaths reportedly confirmed within Vietnam and those reported to the OIE. Our findings, as well as those of studies such as Farnsworth *et al.* (2010), suggest that studies which rely on HPAI H5N1 outbreak data reported to the OIE are likely to be under-estimating the scale of the problem and where possible, studies should endeavour to incorporate local databases into their analyses. The successful prevention of, and response to, infectious disease outbreaks relies on accurate and effective reporting systems being in place (Pittman *et al.* 2007), effective communication channels and the interdisciplinary collaboration of experts across the animal health and public health systems (Roberton *et al.* 2006).

Vietnam is well connected within the international trade networks for animal products, including poultry, and shares its land borders with Laos PDR, Cambodia and the People's Republic of China. Estimates made by the FAO are that 1,593,000 live chickens were imported to Vietnam in 2008 (no data were available for exports; FAOSTAT 2011). When also considering the trade and movement of poultry within the country, the importance of up-to-date and well-communicated disease reporting becomes clear. National borders pay no regard to zoonotic pathogens and when the pathogen in question has the potential to cause widespread economic impacts as well as pose threats to animal and human health, it is imperative that disease surveillance programmes yield comprehensive and accurate data (Kuiken *et al.* 2005) to be communicated with the international community.

Knowledge of HPAI H5N1 outbreaks

With veterinary care and advice for backyard poultry-keeping households being provided by the commune veterinarian, there should be ample opportunity for poultry farmers to receive direct advice and information regarding livestock diseases such as HPAI H5N1. We found that knowledge regarding local HPAI H5N1 outbreaks and the scale of the HPAI problem was poor, particularly given the high proportion of survey households participating in poultry production. Despite close to 90% of the surveyed households participating in poultry-keeping, fewer than 40% of the surveyed households stated that they were aware of HPAI H5N1 having affected their village at any point in the past.

The number of poultry-keeping households with poultry unvaccinated against HPAI H5N1 combined with discrepancies in the reporting of HPAI H5N1 outbreaks at local and national levels and poor knowledge of local HPAI H5N1 outbreaks, prompts questions on whether local veterinary support for rural backyard poultry-keeping households is adequate. For zoonotic diseases such as HPAI H5N1, where the potential for economic and health impacts are high, communication of accurate information and preventive measures from experts through to poultry farmers, is a vital component of successful prevention campaigns for livestock diseases. The demands placed on, and the

problems experienced by, local veterinarians appear to have been acknowledged and improvements to the quality of the veterinary services provided at the farm-level may not be too far away. It was recently announced that $25million had been approved to fund improvements in the quality and effectiveness of the medical and veterinary services provided in Vietnam, with the aim of reducing the risks to people and animals posed by HPAI H5N1 (Xiang 2011). It is hoped that our research will assist in prioritising how best to spend this money to the benefit of the rural Vietnamese communities.

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Chapter 7

Poultry, perceptions and public health: awareness of health impacts in urban poultry consumers.

Live poultry being bled for Tet celebrations in Hanoi. Photo by Kelly Edmunds.

ABSTRACT

Currently circulating strains of Highly Pathogenic Avian Influenza (HPAI) are highly contagious and pathogenic to a broad range of species. These viruses have had significant impact on poultry, particularly in Southeast Asia, where millions of birds have been lost to infection and outbreak control. Poultry losses have widespread impacts causing disruption to food production and livelihood security, affecting the whole poultry trade chain from rural poultry farmers through to urban poultry consumers.

To increase understanding of how HPAI viruses affect urban communities, we investigated the role of poultry for people living in central Hanoi. We examined the awareness that Hanoians have regarding the risks posed by avian influenza and the accuracy of their knowledge. We also explore how Hanoians have altered their behaviour concerning the purchase, preparation and consumption of poultry, in response to perceived health impacts of avian influenza.

We found that poultry is a key protein source for central Hanoians; second only to pork in daily diets and is the preferred meat for special occasions. Most respondents recognise avian influenza as a global problem caused by a virus but few gave accurate answers to questions regarding risks of exposure to, and transmission of this pathogen. Measures employed to protect against avian influenza infection range from large-scale avoidance of situations offering the opportunity for viral exposure, through to traditional and Western medicinal treatment. The majority of respondents adopt measures which acknowledge the presence of this virus within their environment but limit direct exposure opportunities.

INTRODUCTION

The current HPAI strain H5N1 panzootic is the most extensive and expensive animal disease ever recorded (Zessin 2006; Dudley 2008). Currently circulating HPAI H5N1 subtypes are highly contagious causing high mortality in poultry (Gauthier-Clerc *et al.* 2007) as well as in a range of other bird and mammal species (Roberton *et al.* 2006). To date, 562 human cases have been reported resulting in 329 deaths across 12 countries (58.5% mortality rate, WHO 2011). The majority of reported human cases have resulted from close and often prolonged contact with poultry (Beigal *et al.* 2005). Given that frequent and regular close contact between humans and poultry is commonplace in many households in developing countries, relatively few cases of human H5N1 infection have been reported.

The majority of contact between animals and humans arises due to commercial (e.g. farming) and domestic (e.g. backyard poultry) environments (Fielding *et al.* 2005). In 2003, shortly before the first outbreaks of HPAI in Vietnam, it was estimated that there were 254 million poultry birds across the whole country. By 2005 the poultry population had reduced by approximately 15% (Hong Hanh *et al.* 2007). Alongside this decline in poultry numbers, changes are likely to have occurred in the behaviour of poultry consumers and to a lesser extent, poultry farmers/suppliers. Previous studies have shown that consumers alter their behaviour in response to perceived risks relating to food safety (May and Burger 1996; Yeung and Morris 2001) or food-related diseases such as BSE (Bovine Spongiform Encephalopathy; Ngapo 2003). Any changes in human behaviours will have close links to the communication of HPAI H5N1-related information and consequently, the risks people perceive to be associated with poultry.

HPAI H5N1 continues to cause human and poultry deaths and maintains its endemic status across many countries (WHO 2010). Despite continued outbreaks of the virus, the media attention surrounding HPAI H5N1 has reduced substantially. Given the increasing frequency with which emerging infectious diseases are appearing (Jones *et al.* 2008), it is important that we understand how such pathogens are affecting human behaviour so as to be able to address issues such as disease information and vaccination campaigns. Several studies have focused on avian influenza risk perception (see e.g.

Fielding *et al.* 2005; De Zwart *et al.* 2007; Fasina *et al.* 2009) but little attention has so far been given to the changes in human behaviour which may arise from these perceived risks. Here we explore if and how poultry consumers in urban Vietnam perceive avian influenza to threaten their households and whether, as a consequence, they have adapted their behaviour.

This paper investigates the role and importance of poultry to people living in central Hanoi, in 2009-10. We also determine the awareness that Hanoians have regarding risks posed by avian influenza to themselves, their family and the wider Vietnamese community as well as exploring their knowledge of this pathogen. Finally we consider how Hanoians have adapted their behaviour, with regard to the purchase, preparation and consumption of poultry, in response to the perceived health impacts of HPAI H5N1.

METHODOLOGY

Sampling

This study focuses on the residents of Hanoi, Vietnam's capital city, situated within the Red River delta in North Vietnam. With a reported population of close to 6.2 million people (General Statistics Office of Vietnam, 2008); Hanoi is Vietnam's second most populous city. Households were sampled from the four central Hanoi districts (N = 406, giving a 95% confidence level with a 5% confidence interval) with the survey stratified according to district population size (n = 84 in Ba Dinh district, n = 68 in Hoan Kiem, n = 131 in Dong Da and n = 123 in Hai Ba Trung).

Within each district, five streets were randomly selected and along each street, every third household located. Each household was approached and asked if the person responsible for the purchase and preparation of poultry was willing to answer our questions. If they were unavailable, an alternative time to visit was arranged and if they were unable or unwilling to participate, another household was randomly selected. Within each household semi-structured interviews (SSIs) were conducted to explore knowledge, attitudes and the perception of risks associated with poultry and HPAI H5N1. In all households, the SSI was conducted with the person responsible for poultry purchase and preparation.

As this study involves human participants, ethical approval was received from the University of East Anglia's Research Ethics Committee prior to undertaking this research. All SSIs were conducted in Vietnamese by a bilingual researcher who then transcribed the responses into English. To preserve respondents' anonymity, information which could identify individual respondents was recorded separately to SSI responses.

Survey

A standard set of questions (Appendix E) was asked of all respondents, comprising topics of i) household poultry purchasing, preparation and consumption preferences; ii) the keeping of pet birds; iii) participation in merit release practices and iv) knowledge and behaviours associated with HPAI H5N1. Topics i) and iv) are the subject of this paper. Prior to commencing the full survey, a pilot study was conducted with fifty randomly selected respondents. None of the responses from the pilot study are included in this paper.

Questions varied in their answer format with some questions producing quantified data (How much poultry does your household consume each week?); ranked data (What are the three most commonly consumed protein sources in your household?); binary responses (Yes /No or True/False, e.g: Do members of your household eat blood pudding? Can bird flu transmit from human-to-human?) and the majority of questions produced categorical or descriptive responses.

Data analysis

For the questions relating to i) respondents' knowledge of bird flu and ii) the behaviours and actions taken to protect respondents and their family from HPAI H5N1, factor analysis was used to reduce the responses into a concise set of factors which explain much of the variance within the dataset. The scores derived through the factor analysis for each of the entry variables were then put into Generalized Linear Models and regressed against characteristic variables for each respondent including age class,

gender, occupation and household size. All statistical tests were carried out using SPSS v16.0.

RESULTS

Sample population

From the 406 households surveyed, 96.8% of respondents were female (Table 1). The age of respondents was skewed towards those aged 18-29 years (31%, n = 406) with the fewest respondents in the oldest age category of over 60 years (18.2%, n = 406; Table 1). Mean (± SE) household size was 4 ± 0.08 people, giving a total extrapolated sample population across our 406 households of 1856 Hanoians.

Table 1 Characteristics of the participants in a household survey across central Hanoi (*N*=406).

Characteristics		Participants by district (%)				
		Ba Dinh *n* = 84	Dong Da *n* = 131	Hai Ba Trung *n* = 123	Hoan Kiem *n* = 68	Total *n* = 406
Age	18-29	17.8	30.5	33.3	45.6	31.3
	30-44	27.4	36.6	24.4	23.5	28.8
	45-59	34.5	16.8	19.5	19.1	21.7
	Over 60	20.3	16.1	22.8	11.8	18.2
Gender	Male	3.6	3.8	1.6	4.4	3.2
	Female	96.4	96.2	98.4	95.6	96.8
Household size	1	1.2	2.3	0	1.4	1.2
	2	4.8	2.3	0	10.3	3.4
	3	17.9	16.0	13.8	5.9	14.0
	4	31.0	37.4	35.9	32.4	34.8
	5	27.3	23.7	30.9	29.4	27.6
	6	11.8	9.2	15.4	13.2	12.3
	7	1.2	3.1	0.8	4.4	2.2
	8	1.2	0	1.6	1.5	1.0
	9	2.4	1.5	0.8	0	1.2
	10	1.2	3.1	0.8	1.5	1.7
	18	0	0.7	0	0	0.3
	Missing data	0	0.7	0	0	0.3
Occupation	Housewife	28.6	15.3	31.7	4.4	21.2
	Retired	15.5	4.6	0.8	5.9	5.9
	Student	0	0.7	0	0	0.2
	Professional	6.0	11.5	5.7	2.9	7.1
	Unskilled	35.7	51.9	41.4	63.2	47.3
	Own business	9.5	12.2	17.1	22.1	14.8
	Skilled	4.7	3.8	3.3	1.5	3.5

Importance of poultry

Pork was overwhelmingly chosen as the preferred meat source (71.4% of households, *n* = 406) and as the second choice meat source by 23.3% (Figure 1). Chicken was the second most important protein source with 9.9% of households choosing it as their preferred protein source and a further 41.2% choosing it as the second most important (Figure 1).

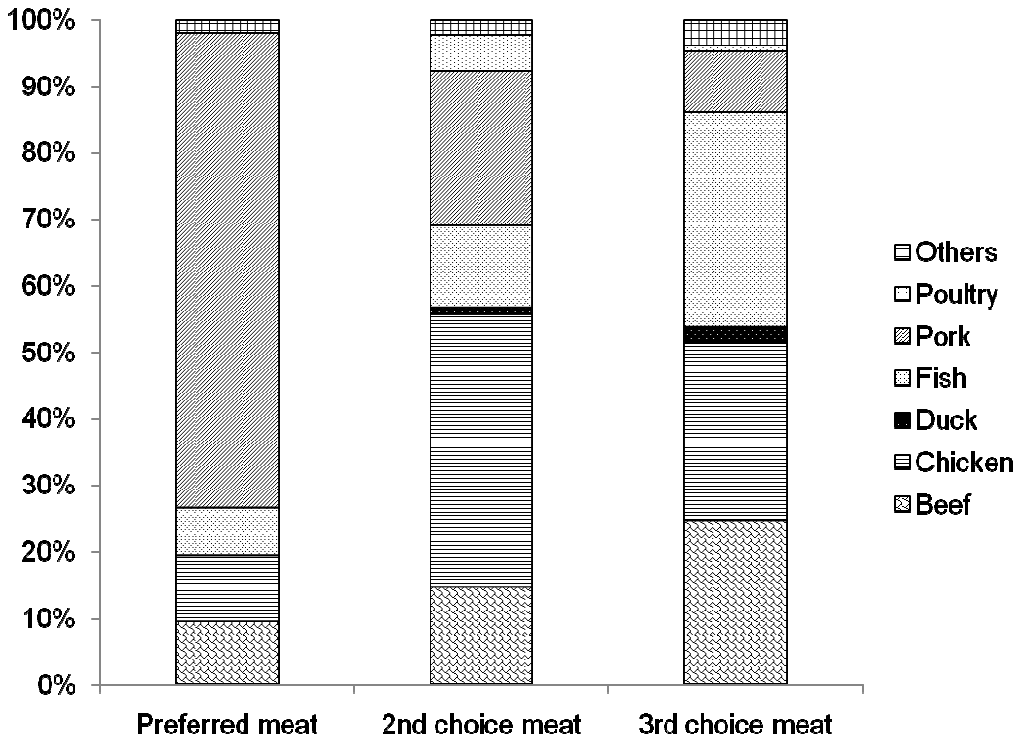

Figure 1 Proportion of respondents of a household survey across central Hanoi (*N*=406) rating the preference of different meat sources for their household's consumption.

It was reported that chicken is a particularly important meat for consumption during special occasions, with 80.8% households eating more chicken at Tet (lunar New Year) and anniversaries of their ancestor's deaths than at other times of the year.

Most of the households surveyed consume 0.5-1 kg of poultry/week with 86% of households eating less than 2kg/week. Taking into account that our survey households have, on average, four residents, this produces an average of <0.25kg of poultry/person/week, of primarily chicken. When this is applied to eggs, most of our survey household consume 6-10 eggs/week, equating to approximately 2 eggs/person/week.

Poultry is typically purchased from local markets (87%, *n* = 406) with slightly fewer than half of those shopping at local markets choosing to purchase their poultry from a familiar stall within the local market (42.8%, *n* =353). Eighteen of those surveyed (4.4%, *n* = 406) preferred to consume poultry which has been raised by their relatives.

Poultry preparation and consumption

The majority of people surveyed (80%, *n* = 406) never slaughter poultry at home and of those that do, slightly fewer than half (46%, *n* = 325) only slaughter poultry in their household for special occasions such as Tet, family weddings or anniversaries of their ancestor's deaths.

Close to sixty percent (58.9%, *n* = 406) of the Hanoians surveyed consume poultry organs. Of these organ consumers, 32 stated which organs they eat as gizzards (81%, *n* = 32), liver (53%, *n* = 32), heart (47%, *n* = 32) and ovaries (3%, *n* = 32). Due to respondents often reporting the consumption of more than one poultry organ, the percentage total is greater than 100. People consume poultry organs in traditional dishes and for special occasions such as Tet. One female respondent reported that the consumption of poultry organs poses little threat to her family's health provided that the organs have been "cleansed with salt".

Few of the respondents currently consume raw blood pudding (4.4%, *n* = 406) and of those who do consume it, only one person stated that they eat it regularly. One respondent told us they "used to eat a lot of tiet canh [blood pudding] but not since bird flu came to Vietnam."

Risk awareness

The majority of respondents (70.2%, *n* = 406) believe that avian influenza is a global disease problem. A further 21.4% of respondents do not know or do not care how widespread avian influenza viruses are. Four respondents (0.9%) believe that avian influenza is a disease restricted to Vietnam.

The majority of respondents (75.9%, *n* = 406) were aware that a virus causes avian influenza although fewer than half of all respondents (44.3%, *n* = 406) know that HPAI strain H5N1 is responsible for causing the recent outbreaks of avian influenza. Other answers given for the causes of avian influenza outbreaks include "the dirty

environment" (one respondent), the weather (two respondents) and swine flu (assumed to be pandemic HPAI H1N1; 5.4%).

Sixty one percent of respondents were aware that avian influenza can affect species other than poultry with 7.6% believing that birds are the species at greatest risk of infection. Fewer than 10% of respondents (n = 406) did not know or did not care about the threats it may pose to wild species. In addition, 8.1% (n = 406) of respondents did not think that wild species can be affected by HPAI and a further 80 respondents were unsure if wild species are susceptible to avian influenza viruses.

Farmers were stated as being those at greatest risk from HPAI H5N1 by more than a quarter of respondents (28.8%, n = 406) closely followed by those coming into regular contact with infected poultry (28.3%). People involved in the sale of poultry and those with weak immune systems were each considered at greatest risk from HPAI H5N1 by almost 20% of respondents (19.5%). The only other people suggested as vulnerable by more than 10% of the respondents were poultry slaughterers (18.7%) and those in unspecified direct contact with poultry (14.5%).

Just over half of the respondents (50.7%, n = 406) believed that the government help or provide support to people or farmers who have been affected by HPAI H5N1 outbreaks. Over one third of respondents (39.4%) stated that they either did not know or did not care if the government helps those affected by HPAI H5N1 outbreaks.

Knowledge of avian influenza

A series of 14 binomial questions with true/false responses were asked to all 406 respondents. These questions explored the respondents' knowledge of bird HPAI H5N1 relating to transmission risks and exposure to the virus. Sixty two respondents (15.3%) correctly answered at least 80% of the fourteen questions asked. Using factor analysis, the responses were then reduced to four separate factors which explain 50.5% of the total variance within the study population (Table 2). Factor 1 represents respondent beliefs regarding HPAI H5N1 affecting wildlife and explains 14.2% of the total variance; factor 2 signifies beliefs behind the transmission of HPAI H5N1 via the

preparation of poultry and contributes 12.8%; factor 3 corresponds to beliefs regarding the transmission of HPAI H5N1 particularly to humans and explains 12.4%, and factor 4 represents environmental exposure and contamination risks for HPAI H5N1, explaining 11.1% of the variance (Table 2).

Table 2 Factors generated using responses from a survey of central Hanoian households (*N*=406) to true/false questions designed to explore the knowledge of avian influenza and associated risks. Factors were extracted from a factor analysis using equamax rotation of the principal components. Explained variance uses the rotated sums of squared loadings. Factor loadings ≥0.5/-0.5 are considered to have an important association between the variable and the factor.

Survey questions	Factors			
	1	2	3	4
Bird flu only transmits from poultry to poultry?			0.67	
Bird flu can transmit poultry to human?			0.80	
Bird flu can transmit human to human?			-0.52	
Bird flu can infect wild birds?	0.90			
Bird flu can infect wild animals?	0.84			
People always die if they catch bird flu?			0.59	
Bird flu can be caught from eating undercooked poultry?				
Bird flu can be caught from eating blood clots?				
Bird flu can be caught from slaughtering poultry?		0.90		
Bird flu can be caught from plucking poultry?		0.89		
Bird flu can be caught from visiting markets?				-0.58
Bird flu can be caught via direct contact with an infected person?				
Bird flu can be caught from contact with poultry dung?				0.55
Bird flu can be caught from contact with contaminated material?				0.86
% of variance explained	14.2	12.8	12.4	11.1
Cumulative variance %	14.2	27.0	39.4	50.5

The factors generated through the factor analysis (Table 2) were regressed against respondent age class, gender, occupation and household size. None of the respondent characteristics were found to significantly predict the generated factors.

Behaviour and risks of health impacts

Each respondent was asked to state, in their own words, what measures they take to protect themselves and their families against HPAI. Based on the responses given, we have arranged these strategies into five categories as shown in Figure 2. The risk of health impacts to an individual increases as one moves further along the categories. The definitions we attribute to each category are:

1. Scenario avoidance - measures taken by a person to prevent placing themselves in a situation where pathogen exposure is likely;
2. Contact avoidance – measures taken when it is accepted that a pathogen is likely to occur within a person's environment that then prevent direct exposure to the pathogen;
3. Infection avoidance – measures taken when a person accepts that exposure to a pathogen is likely to have occurred, and they then attempt to limit the chances of infection;
4. Preparedness – acceptance that the chances of pathogen exposure are high and the subsequent measures taken to prepare for the onset of infection;
5. Treatment – measures taken to improve the chances of fighting off infection.

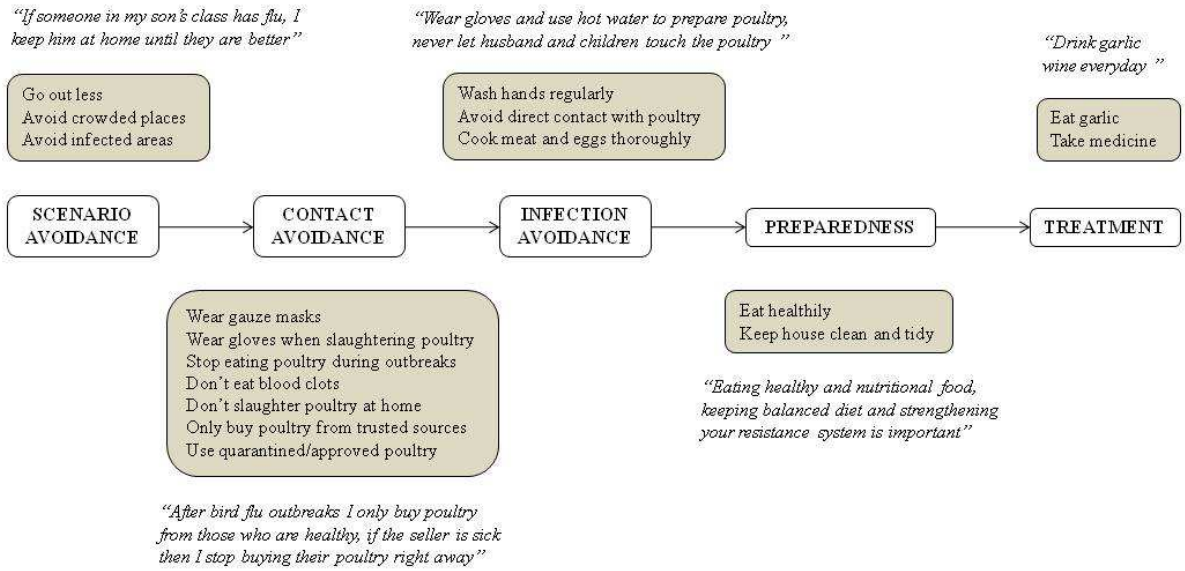

Figure 2 Strategies employed by residents (*N*=406) of central Hanoi to protect themselves and their family from highly pathogenic avian influenza. Shaded boxes list the actions reported within each category. Example quotations are given for each category.

All households reported employing measures to protect themselves against avian influenza. Strategies ranged from those promoting avoidance of the pathogen itself, such as not eating poultry during outbreaks (39.4%) or introducing a physical barrier between a person and the pathogen (36.7%); to actions increasing the likelihood of survival following infection, such as taking medicines (2.2%) or eating garlic (3.7%) and several respondents reported taking no measures to protect themselves or their families (5.4%; Figure 3).

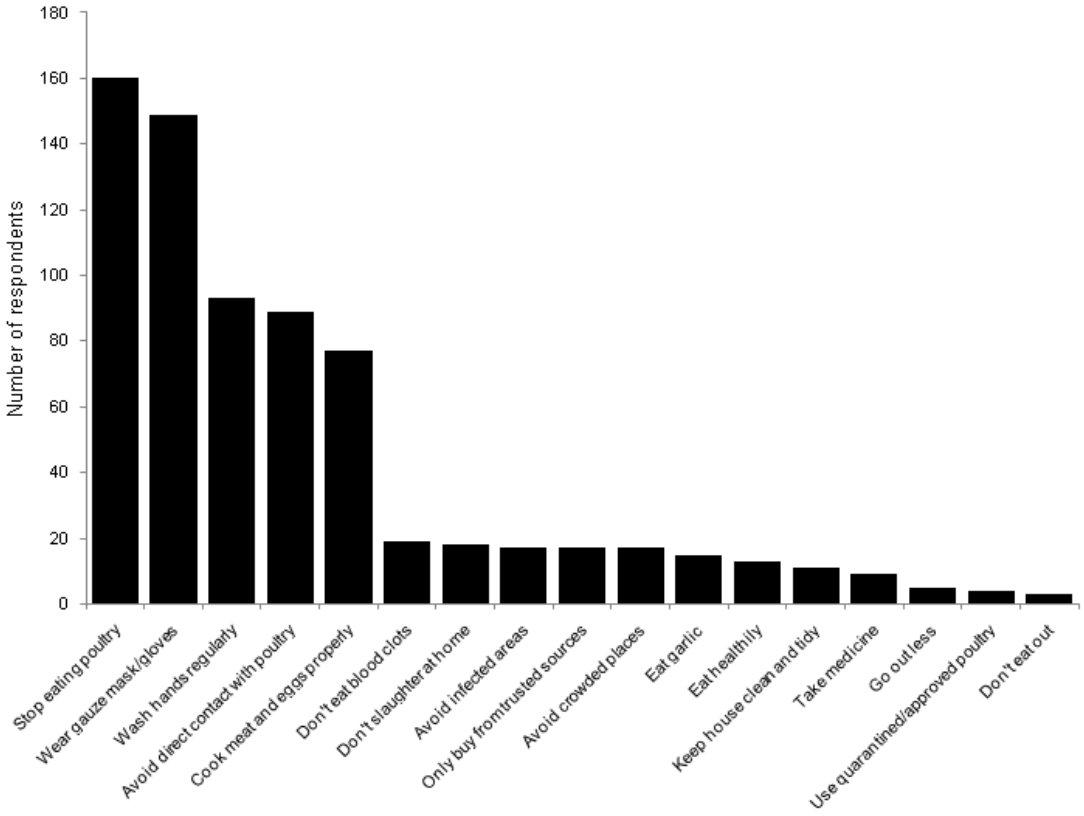

Figure 3 Responses to the question "What measures do you take to protect yourself and your family from avian influenza?" during a household survey across central Hanoi (*N*=406 households).

We asked all 406 respondents which measures they take to protect themselves and their family from avian influenza. Through a factor analysis the responses were reduced into seven separate factors which explain 56.1% of the total variance within the study population (Table 3). Factor 1 represents behaviours which protect the individual from direct contact with HPAI H5N1 virus and explains 9.7% of the total variance; factor 2 reflects behaviours seeking to avoid venturing into "risk" environments and contributes 9.0%; factor 3 corresponds to behaviours which minimise lifestyle changes yet acknowledge HPAI H5N1 poses a risk and explains 8.2%; factor 4 represents behaviours regarding the purchase and preparation of poultry explaining 7.8%; factor 5 identifies with behaviours referring to the consumption of poultry and accounts for 7.3%; factor 6 reflects factors avoiding exposure to the virus and contributes 7.1%, and factor 7 represents behaviours to ensure a healthy individual and explains 7.0% of the total variance (Table 3). The weak explanatory power of this factor analysis shows that respondents choosing to employ any one particular protective measure were not

necessarily any more or less likely to employ any other particular protective measures than the rest of the sample population.

Table 3 Factors generated using responses from a survey of central Hanoian households (*N*=406) to the question "Which measures do you take to protect yourself and your family from avian influenza?" Factors were extracted from a factor analysis using equamax rotation of the principal components. Explained variance uses the rotated sums of squared loadings. Factor loadings ≥0.5/-0.5 are considered to have an important association between the variable and the factor.

Survey questions	Factors						
	1	2	3	4	5	6	7
Avoid direct contact with poultry					0.81		
Wash hands regularly	0.74						
Use quarantined/certified poultry			0.82				
Do not eat blood clots							
Do not slaughter poultry at home				0.85			
Cook meat and eggs properly						0.85	
Do not eat poultry					-0.67		
Wear a gauze mask	0.81						
Eat garlic/drink garlic wine							
Go out less often		0.87					
Avoid crowded places							
Take medicine			0.82				
Eat healthily							0.78
Do not eat out		0.87					
Avoid infected areas						0.58	
Only buy poultry from trusted sources				0.67			
Keep house clean and tidy							
% of variance explained	9.7	9.0	8.2	7.8	7.3	7.1	7.0
Cumulative variance %	9.7	18.7	26.9	34.7	42.0	49.1	56.1

The factors generated through the factor analysis (Table 3) were regressed against respondent age class, gender, occupation and household size. None of the respondent characteristics were found to significantly predict the generated factors.

DISCUSSION

Poultry forms an important source of protein in the diets of central Hanoians; second only to pork as an everyday meat source and the preferred meat for special occasions. Poultry is usually purchased from local markets and many respondents are loyal customers of familiar stalls and vendors. Few respondents slaughter poultry within their households and of the few that do, many of these only participate in this practice on special occasions. Over half of those surveyed consume poultry organs but relatively few consume raw blood pudding. Avian influenza is recognised by the majority of respondents as a global disease problem caused by a virus. However, when asked more specific questions regarding the susceptibility and transmission of avian influenza, far fewer respondents were able to answer our questions correctly. Measures employed to protect against avian influenza infection ranged from avoidance of situations perceived to offer chances of contracting the pathogen through to taking medicine as treatment. The majority of respondents adopt measures which accept the presence of the pathogen within their environment but prevent the opportunity for direct exposure to occur. The bias in our survey towards female respondents highlights that the role of poultry purchasing and preparation usually falls on the females of the household.

Importance of poultry

Chicken is the preferred meat protein source for fewer than 10% of households with more than 70% of households preferring pork. However poultry, particularly chicken, is clearly the second most important meat protein source for the central Hanoi population. Disruption to Vietnam's pig production system would certainly result in increased demand for chicken meat as an alternative to pork. In recent years, Vietnam's pig production chain has experienced outbreaks of a range of diseases and swine are well known as a species in which pathogens can mutate and emerge, particularly influenza viruses (Olsen 2002). Any shift away from pork would increase the pressure on Vietnam's poultry production chain; a system already under stress due to existing demand and competition from overseas poultry imports and still recovering from HPAI H5N1 outbreaks.

Prior to HPAI H5N1 outbreaks occurring in Vietnam, > 95% of total poultry output was sold as live birds from farm gates, in 'wet' (live) markets, rural markets, along road sides as well as in temporary markets within cities (Hong Hanh *et al.* 2007). The central Hanoian residents surveyed during this study purchase their poultry from live markets, usually located in a convenient location close to their home or workplace. This confirms the situation seen in another recent study comparing poultry consumption across Vietnam's two main urban centres, Hanoi and Ho Chi Minh City, which found that almost all Hanoian households shop for food daily and primarily in local markets (Ifft *et al.* 2010).

Average annual meat consumption within Vietnam is estimated at around 40 kg/person (IMCAPI 2010). Comparing this figure to our findings of central Hanoians consuming 0.25kg chicken/person/week, suggests that chicken alone accounts for approximately one third of meat protein consumed by this urban population. With predicted growth for Vietnam's poultry sector and the domination of traditional smallholder production in national poultry output (up to 60% in 2006; Burgos *et al.* 2007; Hong Hanh *et al.* 2007), it is clear that poultry plays an important role as a valuable food source for the urban Vietnamese population as well as for a source of food and income for Vietnam's rural population.

Poultry preparation and consumption

Previous research has shown that Vietnamese poultry consumers react quickly to risks within the poultry trade which pose the potential for personal health impacts, but that these reactions may be short-lived (Figuié & Fourniet 2008). Vietnamese poultry consumers prefer fresh meat and therefore prefer birds to be slaughtered after purchase, a custom which exacerbates the risk of HPAI transmission from poultry to humans (Pfeiffer *et al.* 2007). We found that the majority of Hanoian households do not partake in poultry slaughter themselves and the few that do reserve this practice for special occasions. A recent study found that urban Vietnamese poultry consumers rate HPAI as the most important factor affecting the safety of poultry (Ifft *et al.* 2010).

Whilst poultry meat was found to be one of the most important meat protein sources, the consumption of other poultry products such as organs and raw blood pudding is a much less popular activity. The consumption of high risk poultry products and participation in high risk activities such as the slaughter of poultry, and consumption of sick poultry have been the subject of awareness campaigns aimed at discouraging these activities and promoting behavioural changes (IMCAPI 2010). The shift away from the traditional practice of slaughtering poultry at home and reluctance to participate in the consumption of other poultry products reflects consumer concern that these practices can promote exposure to avian influenza viruses.

Risk awareness

With illegal trade in live poultry continuing to occur in Vietnam's urban centres and a predicted 90% increase in poultry consumption over the next ten years (IMCAPI 2010), the risks to human and poultry health posed by the poultry trade are mounting within Vietnam's urban centres. Our survey found that whilst the majority of respondents are aware of the extent, causes and potential impact of avian influenza, many believe in incorrect information or myths, particularly with regard to the causes and transmission of this pathogen. Various communication campaigns delivered using mass media techniques, community events and training of human and animal health workers have aimed to inform communities about avian influenza and preventive practices (IMCAPI 2010). As the people at greatest risk from HPAI infections are those experiencing close and prolonged contact with poultry, such as poultry market workers and poultry slaughterers (Bridges *et al.* 2002), it may be that communication campaigns have focused on sectors of society situated outside of urban centres. It could be the case that urban consumers, like more than one-fifth of our survey respondents, care little for the scale or extent of avian influenza outbreaks and as such, they give less attention to HPAI communication campaigns, resulting in variable awareness of the risks posed by avian influenza viruses.

Knowledge of avian influenza

The accuracy of a person's knowledge regarding HPAI H5N1 is not related to their age class, gender, occupation or the number of members in their household. However,

knowledge pertaining to HPAI transmission risks and viral exposure can be largely explained by four factors following different themes. The factor explaining the greatest amount of variance in the responses corresponds to the potential for avian influenza to infect wild animals. The positive factor loading value for factor one shows that central Hanoians have a good level of knowledge regarding the potential for avian influenza to affect wild animal populations. HPAI H5N1 has been recorded as a cause of mortality in more than 60 species of wild birds (Olsen *et al.* 2006; Gauthier-Clerc *et al.* 2007) and several mammalian species from a range of orders (see e.g. Kuiken *et al.* 2004; Keawcharoen *et al.* 2005; Roberton *et al.* 2006; OIE 2010). Much media attention has been given to the presence of HPAI H5N1 in wild animal populations, particularly the role which wild migratory birds may be playing in the spread of avian influenza viruses. It is perhaps not surprising that residents within an urban centre such as Hanoi, with a diverse range of media communication outlets, are aware of the presence of avian influenza viruses within wild animal populations.

Risks of avian influenza transmission via the preparation of poultry emerged as the second factor explaining variation in avian influenza knowledge. The third and fourth factors represent beliefs regarding the transmissibility of HPAI H5N1 and the environmental exposure and contamination risks of HPAI H5N1. The factor loadings for all variables included in the first two factors are all positive, suggesting that respondents are providing the correct answers to each statement included in these factors. Both factors three and four however, include variables with negative factor loadings, suggesting that the responses given for these statements were often incorrect. The two statements generating negative correlations with their respective factors cover the transmission of HPAI from human-to-human and whether bird flu can be caught from visiting markets. The incorrect responses given for these statements suggest that false beliefs or myths about these topics may be circulating in central Hanoian households.

Behaviour and risks of health impacts

The central Hanoian public employ a range of measures to protect themselves and their households against avian influenza. These range from scenario avoidance strategies

such as avoiding crowded places through to treating the symptoms of infection. We also found that those respondents employing any one protective measure were no more or less likely to employ any other particular protective measure. Many of these approaches match control measures introduced during the early stages of pandemic influenza outbreaks and involve alterations to common personal and social practices (e.g. wearing gauze masks, regular hand washing and avoidance of public places, etc.; Leppin & Aro 2009). In our study, the approach most commonly implemented is that of contact avoidance, here termed as accepting the presence of a pathogen within one's environment and employing measures to prevent direct pathogen exposure. These measures complement the findings of previous research that direct exposure to infected poultry is the primary risk factor in avian influenza virus transmission from poultry to humans (Abatte *et al.* 2006).

Individual risk perceptions vary, based on the perceived severity of the health threat and consequential vulnerability to oneself (De Zwart *et al.* 2007). Confidence in the ability of the public health authorities to manage threats will also influence the initiation of personal risk prevention strategies (Brug *et al* 2004). As a result, the effectiveness of disease control programmes is fundamentally based on the public's perception of health risks and their subsequent willingness to take up protective measures (Leppin & Aro 2009). We found that Hanoians are prepared to take actions to protect themselves from the risks of infection but few households take more dramatic measures such as ceasing poultry consumption. Poultry has important roles within households, particularly for food during for special occasions. It has already been noted that a possible trigger for the epizootic waves noticed across Vietnam, may be the onset of Tet (Vietnamese New Year) when poultry are brought into households and slaughtered during a traditional ceremony (Martin *et al.* 2006). In order to combat these peaks in human HPAI H5N1 cases, changes to the traditional practices involving within-home rearing and slaughter of poultry would need to take place. Our evidence suggests that central Hanoian households elicit low levels of motivation to participate in personal protective strategies and are reluctant to make significant lifestyle changes in the face of poultry-related potential health impacts. Reasons behind this reluctance to shift away from poultry

consumption may reflect the perceived severity of the threat and the belief that the actions currently taken are sufficient to protect the household.

Protection Motivation Theory links response efficacy (i.e. belief in the success and effectiveness of protection strategies) with self-efficacy (i.e. people's belief in their ability to successfully undertake protective actions) as predictors of protection motivation (Rogers 1983). The motivation for an individual to initiate self-efficacy measures against health threats such as avian influenza is likely to be strongly linked to external factors. To ensure the success of public health campaigns seeking public cooperation and personal responsibility for taking up self-protection strategies, an interdisciplinary approach should be taken to ensure a detailed understanding of the impacts of health threats and their control on individual lifestyles and livelihoods.

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Chapter 8
General Conclusions

Zoonoses and emerging infectious diseases (EIDs) are appearing with increasing frequency (Jones *et al.* 2008). There are significant gaps in our knowledge of even the most studied and well-known EIDs and in order to develop our understanding of the social, environmental and ecological impacts of such diseases, a holistic and interdisciplinary perspective is required (Wilcox and Colwell 2005). Whilst the majority of zoonotic and vector-borne diseases are known to have links with the natural environment, the links between disease epidemiology, human interaction and natural processes has only recently started receiving significant research attention (Wilcox and Colwell 2005). The ability of highly pathogenic avian influenza (HPAI) strain H5N1 to infect and cause mortality across a broad range of taxa, both wild and domestic (including insects, birds and mammals, including humans, Appendix A) has resulted in this particular EID receiving substantial attention from the world's media, scientific community and the general public. Interest in this strain of the virus initially focussed on the direct impacts to human health and domestic poultry flocks, particularly its virology, pathogenicity and geographic spread. However, it soon became clear that certain aspects of HPAI H5N1 epidemiology and the indirect impacts of outbreaks of this strain had been neglected. Through employing a range of techniques across the disciplines of biology, ecology, social science and epidemiology, the research presented in this thesis attempts to address these knowledge gaps and highlight the importance of interdisciplinary research in tackling EID outbreaks.

Responding to emerging infectious disease outbreaks

The recent increase in the incidence of EIDs has been attributed to a range of factors, including more frequent and rapid human global travel, increased human population density, translocation of animal species, changes in agricultural practices and poorly focused health monitoring (Binder *et al.* 1999; Daszak *et al.* 2000; Bell *et al.* 2004; Jones *et al.* 2008). HPAI H5N1 has been affected by several of the causal factors attributed to the increasing occurrence of EIDs and following its transmission across

three continents, is now known to be the most extensive and expensive animal disease ever recorded (Zessin 2006; Dudley 2008). The economic cost of HPAI H5N1, estimated in 2005 at ~$10 billion in Southeast Asia alone (FAO 2005) with annual costs to the Vietnamese government of tens of millions of dollars (FAO 2011), has largely been as a result of the investment into control programmes, research into vaccines and to compensate those who have lost their birds during outbreaks. Identifying a low-cost and rapid method to respond to disease outbreaks such as these has obvious financial, public health and veterinary benefits, particularly when the outbreaks are a threat to developing countries already experiencing severe issues related to public health and poverty. In Chapter 2 we consider the potential for the Hazard Analysis of Critical Control Points (HACCP) technique as a tool to be used in the rapid response to EID outbreaks. We apply this technique to Vietnam's poultry trade and the HPAI viruses, a system which allows us to assess the risks related to a specific emerging health threat, closely linked to food production within a known zoonotic and emerging infectious disease hotspot.

Our analysis provides strong evidence for the potential that HACCP assessments may have in the early stages of responding to emerging health threats. They provide a rapid means of producing evidence-based recommendations within days of an outbreak occurring; in contrast to the time and expense which in-depth epidemiological studies require. We identify the risk factors associated with HPAI virus transmission and make recommendations for simple preventative measures which, if employed on a broad scale, should reduce the occurrence of HPAI outbreaks. This chapter also presents the idea that a lack of veterinary resources, including specialist knowledge, training and expertise, as well as the pressure put upon local veterinarians, may be exacerbating the transmission of highly contagious pathogens such as HPAI viruses and other livestock diseases within Vietnam. Whilst control programmes and public health are obvious priorities for financial investment, the importance of ensuring that on-the-ground veterinary services are fulfilling the needs of those with animals affected by zoonotic EIDs should not be underestimated.

Live birds and disease transmission

HPAI H5N1 is known to infect and be pathogenic in numerous mammal and primarily bird species (Gauthier-Clerc *et al.* 2007) with a rarely seen ability to cross species barriers. The current HPAI epidemic is directly related to infected birds sold live in traditional markets (Chomel *et al.* 2007) as well as the movement of infected birds and materials (Alexander 2000; Capua and Marangon 2006; Olsen *et al.* 2006; FAO 2011). As a result of research which found that live bird markets may have been involved in fatal human infection with HPAI H5N1, the recommendation was made that the sale of live birds directly to consumers should be discouraged in areas experiencing influenza outbreaks amongst birds, particularly within large modern cities (Mounts *et al.* 1999; Wang *et al.* 2006). The live bird trade brings together birds and humans from various localities mixing and congregating within one arena; ideal for the transmission of zoonotic pathogens such as HPAI viruses, giving rise to the potential for virus re-assortment (Nguyen *et al.* 2005).

It was with this in mind that we undertook a survey of the major urban centres within Vietnam; a country which maintains its HPAI H5N1 endemic status as well as a strong cultural affinity towards the keeping of live birds. Chapter 3 goes some way towards addressing this knowledge gap by focusing on the under-studied ornamental live bird markets within Vietnam; presenting the findings from surveys across these live bird markets and a series of interviews conducted with live bird vendors. We report a five-fold increase over a two-year period, in the volume of the trade within Vietnam's capital city of Hanoi and alongside this we also see 95% of Hanoi's wild bird vendors claiming that they are unaware that their chosen trade is almost wholly illegal. When this is coupled with a further finding that 25% of the species commonly seen within these markets are known to be susceptible to HPAI H5N1 infection, the potential role that Hanoi's ornamental bird markets may play in the spread of HPAI H5N1 virus is cause for concern.

In addition to the disease risks posed by such an unregulated trade in wild birds, Chapter 3 also gives rise to concern regarding the status of wild populations of the targeted bird species. With trapping of wild birds for the international bird trade having

been identified as a threat to the survival of one in twenty bird species considered to be threatened or near-threatened (BirdLife International, 2011) the expansion of such a trade within a country known to be a supply hub for the global wildlife trade network is certainly cause for alarm.

Following on from the research presented in Chapter 3 which considers Vietnam's live bird trade from the market-based perspective, we then wanted to better understand this trade from the perspective of the demand for birds. Within Vietnam, and the larger Southeast Asian region, the trade in live wild birds is largely fuelled by demand for birds as a means of livelihood through trade, to release during religious ceremony or as an ornamental attraction (Karesh *et al.* 2007). Chapter 4 presents the results from our investigations into popular cultural practices within Vietnam and Thailand which exploit live wild birds and we consider how these practices may be contributing to the transmission of zoonotic pathogens, particularly HPAI H5N1.

The role of traditional or cultural practices as a means of disease transmission and the impacts of these practices on biodiversity exploitation are largely under-studied. The relationship between people and birds in Southeast Asia has a long history and in many parts of the region, bird-keeping forms an important part of local culture and tradition (Thomse *et al.* 1992; Nash 1994). These practices are another mechanism which brings people and wildlife from a range of locations into close contact with each other, promoting interactions at the human-animal interface. To enable us to understand the role which humans may play in driving the transmission of HPAI H5N1 virus, we consider three traditional pastimes popular within Vietnam and Thailand; songbird contests, religious merit release practices and fighting cock contests. Improving our understanding of the tradition behind these practices will assist with ensuring that these practices can continue in a manner that is both sustainable for the biodiversity, maintains cultural heritage and also minimises the health threats to both human and animal populations.

Each of the practices considered in Chapters 3 and 4 were found to present human-animal interfaces which provide opportunities for pathogen transmission between

animals as well as from animals to humans. Whilst all the practices were accessible at some level to all income and age strata, songbird contests and fighting cock contests were heavily male-dominated whilst religious merit releases mostly consisted of female participants. Participation in these practices is usually for actual personal gain through acquiring wealth, prestige or increased social status, or for prospective benefits through the release of "captive" animals alongside prayers made to the Gods, usually asking for blessings and good fortune. In terms of risks for disease transmission, the greatest risks come from the numbers of animals involved and the distances covered when transporting the birds to contests. For the religious merit release practices, our study calculates a conservative minimum estimate of 3,000,000 birds extracted from the wild each year to meet the demand for these ceremonies in Vietnam alone. When this massive number is also combined with injury risk on capture, the conditions that the birds are kept in during transportation and prior to release and the mixing of the birds under these poor hygiene conditions, there is a high probability that these practices are a high risk activity for pathogen transmission as well as a threat to biodiversity. The bird species exploited through these practices are not currently considered threatened under the IUCN categories of extinction risk, however continued exploitation at this scale is likely to help drive these species closer towards extinction.

For both the songbird contests and fighting cock contests, the number of birds is significantly fewer than seen with the merit release practices, however the owners of the birds transport them over vast distances, up to several hundred kilometres, to attend these prestigious and lucrative contests. Birds carrying pathogens, which like HPAI H5N1 are easily shed by the living hosts and survive particularly well in damp and humid environments (Jourdain *et al.* 2007), may then act as live vectors for the virus, particularly within this tropical region. In the case of the fighting cock competitions, the bird owners consider the health of the birds to be a priority and as such, think nothing of placing their own well-being before that of the birds. Considering all of these points, preventing these practices from impacting upon either ecosystem health or public health systems will require careful and considered management. These practices hold a long history of tradition within their particular cultures as well as their roles within society and this cultural importance should not be overlooked. However, without intervention it

is likely that the substantial impacts of these practices on wild bird populations as well as the risks for public health will result in widespread and potentially irreversible damage to ecosystem integrity.

Chapters 3 and 4 highlight the potential that unregulated and unmonitored activities involving wild-caught animals may have for the transmission of zoonoses as well as overall ecosystem function and services. Chapters 5 and 6 move on to consider how outbreaks of HPAI H5N1 may be affecting rural communities, particularly those households participating in backyard poultry production.

Impacts of HPAI H5N1 at the household level

Rural households

Poultry require minimal financial investment, space and financial input and as a result, backyard poultry production provides the rural poor with the opportunity to participate in an alternative livelihood with the potential to lift them out of poverty (Sonaiya 2007). Within rural Vietnam the majority of households participate in backyard poultry production, and whilst it provides just a small proportion of total household income (Epprecht *et al.* 2007), it also provides a year-round source of protein for household consumption (Otte *et al.* 2006; Hong Hanh *et al.* 2007). Of the 218 rural households surveyed for Chapters 5 and 6, 89% participate in backyard poultry production. This equates to a high proportion of rural households which are vulnerable to the direct impacts of HPAI H5N1 outbreaks; loss of their poultry flock results in reduced income and a reduced availability of an easily accessible protein source. Due to the potential for HPAI H5N1 outbreaks to cause widespread disruption to rural backyard poultry flocks across Vietnam and the likelihood for such outbreaks to recur, Chapter 5 sought to understand what drives poultry farmers to persist with the keeping of poultry despite the financial risk and risk of health impacts for themselves and their families.

The data presented in Chapter 5 and to a lesser extent, Chapter 6, demonstrate the strong attachment which rural Vietnamese people exhibit towards the keeping of household poultry. Whilst the surveyed households reported livelihood instability as a result of HPAI H5N1 outbreaks affecting their household poultry, the majority of affected

households chose to persevere with the keeping of their household poultry rather than taking up an alternative occupation. This ability to tolerate the pressure of external stresses acting on their livelihoods demonstrates the resilience of these rural Vietnamese communities. Whereas it would typically be expected that households might adopt a livelihood diversification strategy in the face of livelihood instability (Ellis 2000), our research has found the converse to be the case for households farming poultry. In Chapter 5 we suggest four possible drivers for this persistence with poultry which can broadly categorised as i) a lack of resources to aid diversification, ii) a lack of knowledge regarding alternatives, iii) poor access to alternative livelihoods and iv) reluctance to diversify due to cultural affinity. Perhaps an alternative explanation for the persistence with poultry is simply that poultry production is easy to participate in and requires minimal initial investment and maintenance costs and so are considered relatively low risk from a financial perspective. When this is combined with the traditional nature of poultry keeping, perhaps poultry farmers choose to persist with poultry production at the risk of disease outbreaks, unstable markets and additional debt rather than enter a new world of unknown risks through a change of livestock, occupation and/or livelihood diversification.

To build upon the research of Chapter 5 and expand our knowledge of the role of poultry within rural Vietnamese households and consequently, the impact of disease outbreaks on these households, Chapter 6 reports on local reporting of HPAI H5N1 outbreaks, household poultry farmer knowledge of HPAI H5N1 and the subsequent efforts made to protect poultry from disease outbreaks.

Based largely on their personal knowledge and advice received from the local DAH, rural households make decisions concerning the measures they are prepared to take to protect their livestock from disease outbreaks. Chapter 6 reports on a range of actions employed and measures taken by rural households to protect their poultry from HPAI H5N1 outbreaks. These measures ranged from participation in the official vaccination campaigns through to providing poultry with garlic or rice wine as a preventative treatment against the H5N1 influenza virus. Traditional and modern medicines overlap with each other (Schillhorn van Venn 1997) in terms of usage, support and promotion.

This is particularly the case in Southeast Asia where traditional medicines are widespread yet provisions for Western-style veterinary care and facilities are provided through international aid organisations and government aid agencies such as the World Health Organisation and the Centers for Disease Control and Prevention. Our surveys found a large number of rural Vietnamese poultry farmers administer alternative medicines to their poultry. Whilst farmers are known to undertake their own medicinal experiments in the search for alternative treatments for their livestock (Schillhorn van Venn 1997) and believe these practices to be effective, more applied research into the use of traditional/unconventional interventions is needed.

Despite rural Vietnamese households choosing to persist with the keeping of backyard poultry flocks in the face of disease risks and livelihood instability (see Chapter 5), the poultry kept by greater than one-quarter of these households are lacking up-to-date vaccinations. Whilst the use of unvaccinated sentinel birds has been suggested as a method for detecting HPAI H5N1 outbreaks and mitigating inter-flock virus spread (see e.g. EC 2006; Savill *et al.* 2006), the use of such vaccination strategies was not employed in our survey communities. The reasons given for why birds were lacking up-to-date vaccinations was largely due to a lack of knowledge regarding HPAI H5N1 by the poultry owners or missed opportunities to vaccinate when the local Department of Animal Health (DAH) carried out their biannual vaccination rounds. When this is combined with more than half of our survey households not being aware of the HPAI H5N1 outbreaks which have affected their village, the lack of accurate knowledge regarding HPAI H5N1 is clearly influencing how these rural households are deciding how to protect their poultry flocks, and consequently their household livelihoods, against poultry disease outbreaks.

Rural Vietnamese households typically keep more than one type of livestock (Burgos *et al.* 2008) and it is likely that decisions made to protect all household livestock are based upon similar levels of knowledge regarding disease risks and outbreaks. With outbreaks of, amongst others, Foot-and-Mouth disease and Newcastle disease also affecting Vietnam's livestock in 2011 (OIE 2011), ensuring that households whose livelihood stability is dependent on livestock are able to make informed decisions about protecting

their animals from disease outbreaks, should be a priority for the local veterinary services. The US $25 million recently approved to improve Vietnam's medical and veterinary services with the aim of reducing the risks to people and animals posed by HPAI H5N1 (Xiang 2011), is welcome news but well-managed allocation of these funds is required to ensure they reach the veterinarians working with farmers at the household level.

The research within Chapter 6 also shows there to be massive discrepancies between locally reported HPAI H5N1 outbreaks and the number of outbreaks reported to a widely used global database, managed by the World Organisation for Animal Health (OIE). When we compared the local HPAI H5N1 outbreak reports with those held by the OIE, we find there to be substantial under-reporting of HPAI H5N1 outbreaks to the global database. Such findings have also been seen in comparisons made with other global disease outbreak databases (see e.g. Farnsworth *et al.* 2010) and present significant problems for estimating the extent and scale of disease outbreaks as well as the implementation of disease prevention and response programmes. For studies which base their calculations and findings on the data held within these databases there are also issues relating to the reliability of predictive modelling; such studies should be conducted with caution and where possible, also incorporate the use of local disease outbreak reports.

Urban households

The final data chapter in this thesis considers the under-studied impacts of HPAI H5N1 outbreaks on urban households. Urban households for whom poultry is a key protein source may be affected by HPAI outbreaks which occur further up the poultry production chain, affecting the supply of poultry meat and products. Continuing the exploration of impacts of HPAI H5N1 within Vietnam, Chapter 7 utilises data collected through a survey of 406 households from central Hanoi to address a key socio-economic question regarding HPAI H5N1; how do HPAI viruses impact upon urban communities? In order to answer this question, data were collected which addressed issues relating to public health, human behaviour and risk aversion.

Poultry is a key source of protein for central Hanoians fulfilling an important role in their diets, particularly for special occasions, but rarely playing any role in household income. With almost all households surveyed listing poultry as an important source of protein for consumption it might be reasonable to assume the majority of households would be aware of the risks of exposure to raw poultry and transmission of HPAI H5N1 virus, however this was not the case. Whereas all households employ some form of protective measures against avian influenza infection, few respondents were able to accurately answer questions relating to H5N1 exposure risks suggesting that the protective measures taken are likely to be broad-scale avoidance of the pathogen itself. Indeed it was found that the majority of respondents adopt protective measures which exhibit contact avoidance behaviour. We consider these to be measures which acknowledge that the presence of HPAI H5N1 within an environment is likely, but the measures employed limit the opportunity for direct virus exposure. These measures include behaviours such as ceasing the consumption of poultry and the wearing of gloves or gauze masks.

Whilst Vietnamese poultry consumers prefer fresh meat (Pfeiffer *et al.* 2007), only the minority of our surveyed urban households participate in home slaughtering of poultry and usually then only for special occasions. As the people at greatest risk from HPAI infections are those experiencing close and prolonged contact with poultry (Bridges *et al.* 2002), households which choose not to slaughter poultry at home reduce their HPAI exposure risk. This risk aversion behaviour however, is not necessarily based on reliable knowledge as we found that many of the urban respondents believe incorrect information when it comes to the causes and transmission of HPAI H5N1.

Finally Chapter 7 describes how, in response to perceived risks of health impacts due to poultry, central Hanoians are prepared to undertake actions to protect themselves from HPAI H5N1 infection and limit the opportunities for infection, although few households take up more extreme measures such as permanently ceasing poultry consumption or employing a series of simultaneous protective measures.

Future directions

This thesis set out to demonstrate how employing a range of techniques from multiple disciplines can produce results and recommendations which are of benefit to several sectors of ecological and health research. In order to fulfil this aim, this thesis has collated quantitative and qualitative data collected through methods including structured and semi-structured interviews, direct surveys and the development of a theoretical framework, to address issues relating to EIDs, specifically HPAI H5N1, in relation to i) their epidemiology and control, offering recommendations of benefit to the public health and disease control arenas (Chapter 2); ii) their impacts within the fields of ecology, conservation, ethno-ecology, disease epidemiology and anthropology (Chapters 3 and 4) and iii) knowledge gaps within the social science, public health and health protection arenas (Chapters 5, 6 and 7).

There are inherent difficulties in conducting interdisciplinary research, not least of all the range of methodologies which need to be employed. Highlighting these difficulties as well as developing and disseminating potential solutions, perhaps through a synthesis of the approaches and methodologies employed throughout the research within this thesis, is a key aspect of this research which would benefit from further development. The impacts of EID outbreaks span the areas of ecological, social and environmental science as well as having impacts on public health and economics and finding workable solutions which help to tackle the problems of the interdisciplinary nature of the issues is fundamental to ensuring future success in tackling EID outbreaks.

Expanding the research approach outside of Vietnam to cover neglected EIDs, or a range of EIDs such as the newly emerging Henipaviruses in Southeast Asia, or indeed to cover vector-borne diseases such as malaria and dengue haemorrhagic fever across many regions of the developing world, would provide a greater understanding of the wide-ranging impacts of such diseases on the social, ecological, public health and environmental sectors, and in the long-term assist in combating these important and emerging disease threats.

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APPENDIX A List of all species with reported HPAI H5N1 infections. Where known, the wild/captive state for each bird reported is given along with whether the infection was fatal (+) or not (-). This table has been modified from USGS (2011) and expanded with species detailed in additional reports (BirdLife 2006, ProMED mail 2010a, 2010b, 2010c, 2011a, 2011b, 2011c, OIE 2011).

Class: Aves				
Order: Anseriformes		Wild	Captive/Domestic	Fatal
Aix galericulata	Mandarin duck	+		+?
Aix sponsa	Wood duck		+	+
Alopochen aegypticus	Egyptian goose		+	+
Amazonetta brasiliensis	Brazilian teal		+	+
Anas acuta	Northern pintail		+	+
Anas bahamensis	Bahaman pintail		+	+
Anas castanea	Chestnut-breasted teal		+	+
Anas crecca	Blue-winged teal		+	-
Anas formosa?	Baikal teal?	+		+
Anas penelope	Eurasian wigeon	+	+	+
Anas platalea	Argentine shoveller		+	+
Anas platyrhynchos	Domestic duck/Mallard	+	+	+
Anas sibilatrix	Chile wigeon		+	+
Anas strepera	Gadwall	+	+	-
Anas versicolor	Puna teal		+	+
Anas undulata	Yellow-billed duck		+	?
Anser albifrons	Greater white-fronted goose	+		+
Anser anser	Greylag goose	+		+
Anser anser domesticus	Domestic goose		+	+
Anser erythropus	Lesser white-fronted goose	+		+

Anser indicus	Bar-headed goose	+		+
Aythya americana	Redhead		+	+
Aythya ferina	Common pochard	+	+	-
Aythya fuligula	Tufted duck	+	+	+
Aythya marila	Greater scaup	+		+
Branta bernicla	Brent goose		+	+
Branta canadensis	Canada goose		+	+
Branta hutchinsii	Cackling goose			+
Branta leucopsis	Barnacle goose	+		-
Branta ruficollis	Red-breasted goose	+		+
Cairina moschata	Musovy duck		+	
Callonetta leucophrys	Ringed teal		+	+
Chenonetta jubata	Manned wood-duck		+	+
Coscoroba coscoroba	Coscoroba swan		+	+
Cygnus atratus	Black swan		+	+
Cygnus buccinator	Trumpeter swan			+
Cygnus cygnus	Whooper Swan	+		+
Cygnus melanocoryphus	Black-necked swan		+	+
Cygnus olor	Mute swan	+		+
Dendrocygna javanica	Lesser whistling-duck	+		?
Dendrocygna viduata	White-faced whistling-duck		+	+
Mergus albellus	Smew	+		+
Mergus merganser	Goosander	+		+
Nesochen sandvicensis	Hawaiian goose		+	+
Netta peposaca	Rosybill pochard duck		+	+

Netta rufina	Red-crested pochard		+	+
Oxyura jamaicensis	Ruddy duck		+	+
Tadorna ferruginea	Ruddy shelduck	+		+
Order: Charadriformes				
Larus argentatus	Herring gull	+	+	+
Larus atricilla	Laughing gull		+	-
Larus brunnicephalus	Brown-headed gull	+	+	+
Larus canus	Mew gull	+		?
Larus ichthyaetus	Great black-headed gull	+	+	+
Larus ridibundus	Black-headed gull	+		+
Larus schistisagus	Slaty-backed gull	?	?	?
Numenius arquata	Eurasian curlew	+		
Tringa gareda	Wood sandpiper	+		?
Tringa ochropus	Green sandpiper	+		-
Order: Ciconiiformes				
Anastomus oscitans	Asian open-billed stork	+	+	+
Ardea cinerea	Grey heron	+	+	+
Ardea herodias (?)	Great blue heron	+		+
Ardea purpurea	Purple heron		+	+
Ardeola bacchus	Chinese pond heron	+		+
Ardeola speciosa	Javan pond heron		+	+
Balearica regulorum	Grey crowned crane	+		-
Bubulcus ibis	Cattle egret	+		
Carmerodius albus	Great egret	+		+
Ciconia ciconia	White stork	+		+

Egretta garzetta	Little egret	+	+	+
Ephyppiorhnychus asiaticus	Black-necked stork		+	+
Leptoptilus dubius	Greater Adjutant stork		+	+
Leptoptilus javanicus	Lesser Adjutant stork		+	+
Mycteria leucocephala	Painted stork		+	+
Nycticorax nycticorax	Black-crowned night heron	+		+
Order: Columbiformes				
Chalcophaps indica	Green-winged pigeon	+		?
Columba livia	Feral pigeon	+	+	+
Geopelia striata	Zebra dove	+		?
Macropygia ruficeps?	Little cuckoo dove	?		?
Streptopelia chinensis	Spotted dove	+		?
Streptopelia tranquebarica	Red-collared dove	+		+
Order: Coraciiformes				
Buceros bicronis	Great hornbill		+	+
Merops philippinus	Blue-tailed bee-eater	+		-
Order: Falconiformes				
Accipiter gentilis	Northern goshawk	+		+
Accipter nisus	Sparrowhawk	+		+
Accipter trivirgatus	Crested goshawk	+		+
Bubo sp?	“Eagle owl”	+		+
Buteo buteo	Buzzard	+		+
Buteo lagopus	Rough-legged buzzard	+		+
Circus aeruginosus	Western Marsh-harrier	+		+
Falco cherrug	Saker falcon		+	+

Falco peregrinus	Peregrine falcon	+	+	+
Falco sparverius	American kestrel		+	+
Falco tinnunculus	Common kestrel	+		+
Gyps sp?	"wild vulture"	+		+
Gyps bengalensis	White-rumped vulture		+	+
Haliastur indus	Brahminy kite		+	+
Ichthyophaga ichthyaetus	Grey-headed fish-eagle		+	+
Ichtinaetus malayensis	Black eagle		+	+
Milvus migrans	Black kite	+		-
Necrosyrtes monachus	Hooded vulture	+		+
Spilornis cheela?	Serpent eagle		+	+
Spizaetus cirrhatus	Changeable hawk eagle		+	+
Spizaetus nipalensis	Crested hawk-eagle	+		-
Spizaetus nipalensis orientalis	Hodgson's hawk eagle	+		+
Order: Galliformes				
Alectoris chukar	Chukar partridge		+	+
Chrysolophus pictus	Golden pheasant	+		?
Colinus virginianus	Bobwhite quail		+	+
Corurnix coturnix japonicus	Japanese quail		+	+
Gallus domesticus	Domestic chicken		+	+
Lophura leucomelanos	Kalij pheasant	+		+
Lophura nycthemera	Silvered pheasant	+		?
Meleagris gallopavo	Turkey		+	+
Numida meleagris	Pearl guineafowl		+	+
Pavo cristatus	Peacock		+	+

Pavo cristatus albus	White Indian peafowl	+		+
Pavo muticus	Green peafowl		+	+
Phasianus colchicus	Ring-necked pheasant		+	+
Order: Gruiformes				
Amauronis akool?	Brown (red-legged) crake	+		+
Chlamydotis undulata	Houbara bustard	+		+
Fulica atra	Common coot	+		-
Gallicrex cinerea	Watercock		+	
Gallinula chloropus	Common moorhen	+		+
Grus antigone	Sarus crane		+	+
Grus monacha	Hooded crane		+	+
Grus nigricollis	Black-necked crane	+		+
Porphyrio porphyrio	Moorhen (Purple swamphen)	+		+
Order: Passeriformes				
Acridotheres cristatellus	Crested mynah	+		+
Acridotheres grandis	White-vented mynah	+		?
Acridotheres tristis	Common mynah	+		?
Alauda arvensis	Eurasian skylark	+		?
Alcippe morrisonia	Grey-cheeked fulvetta	+		?
Carpodacus mexicanus	House finch		+	+
Copsychus saularis	Oriental magpie robin	+		+
Corvus cornix	Hooded crow	+		+
Corvus corone	Carrion crow	+		?
Corvus frugilegus	Rook	+		?
Corvus macrorhynchos	Jungle/Large billed crow	+		+

Corvus monedula	Jackdaw	+		+
Corvus splendens	House crow	+		+
Dicrurus macrocercus	Black drongo	+		?
Gracula religiosa	Hill mynah		+	+
Hirundo rustica	Barn swallow	+		+
Hypsipetes leucocephalus	Asian black bulbul	+		?
Lanius schach	Long-tailed shrike		?	+
Leiothrix argentauris	Silver-eared mesia		+	+
Leiothrix lutea	Red-billed leiothrix		+	+
Leucosticte nemoricola	Plain mountain-finch	+		?
Lonchura atricapilla	Chestnut munia	+		+
Lonchura punctulata	Scaly-breasted munia	+		?
Lonchura sp.	Munia	+		+
Lonchura striata	White-rumped munia	+		+
Oriolus chinensis chinensis	Black-naped oriole		+	+
Orthotomus spp.	“Long-tailed” tailorbird	+		?
Parus monticolus	Green-backed tit	+		?
Passer domesticus	House sparrow		+	-
Passer montanus	Eurasian tree-sparrow	+		+
Petronia petronia	Rock sparrow	+		?
Pica pica	European magpie	+		+
Pica pica sericea	Korean magpie	+		+
Pycrionotus jocosus	Red-whiskered bulbul	+		?
Pyrrhocorax pyrrhocorax	Red-billed chough	+		+
Sturnus contra	Asian pied starling	+		-

Sturnus nigricollis	Black-collared starling	+		?
Sturnus sericeus	Red-billed starling	+		+
Sturnus sturninus	Daurian starling		?	+
Sturnus vulgaris	European starling	+		-
Taeniopygia guttata	Zebra finch			+
Turdus merula	Eurasian blackbird	+		?
Urocissa erythrorhyncha	Blue magpie		+	+
Yuhina diademata	White-collared yuhina	+		?
Zoothera dauma	Eurasian scaly thrush	+		?
Zosterops japonicus	Japanese white-eye	+		+
Order: Pelecaniformes				
Peleccanus philippensis	Spot-billed pelican			
Pelicanus sp.	Pelican	+		+
Phalacrocorax carbo	Great cormorant	+		+
Phalacrocorax niger	Little cormorant	+		?
Platalea leucordia	Eurasian spoonbill	?		?
Order: Phoenicopteriformes				
Phoenicopterus ruber	Greater flamingo		+	+
Order: Podicipediformes				
Podiceps cristatus	Great crested grebe	+		-
Podicepts nigricollis	Black-necked Grebe	+		+
Tachybaptus ruficollis	Little grebe	+		+
Order: Psittaciformes				
Melopsittacus undulatus	Budgerigar		+	+
Pionus menstruus	Blue-headed pionus		+	+

Order: Strigiformes				
Bubo bubo	Eurasian eagle-owl	+		+
Bubo nipalensis	Spot-bellied eagle-owl		+	+
Ketupa ketupu	Buffy fish-owl		+	+
Ketupa zeylonensis	Brown fish-owl		+	+
Otus spp.	Scops owl		+	+
Strix seloputo	Spotted wood-owl	+		+
Strix uralensis	Spotted wood-owl		+	+
Tyto alba	Barn owl		?	+
Order: Struthioniformes				
Dromaius novaehollandiae	Emu		+	-
Struthio camelus	Ostrich		+	+
Class: Insecta				
Aldrichina grahami	Blow fly	+		-
Calliphora nigribarbis	Blow fly	+		
Culex tritawniorhynchus	Mosquito	+		
Class: Mammalia				
Order: Artiodactyla				
Sus domesticus	Pig		+	-
Order: Carnivora				
Canis familiaris	Domestic dog/feral dog	+	+	+
Catopuma temminckii	Asian golden cat		+	-
Chrotogale owstoni	Owston's Palm Civet		+	+
Felis domestica	Domestic cat/feral cat	+	+	+
Martes foina	Stone (beech) marten	+		+

Mustela lutreola	European mink	+		+
Mustela putoris furo	Ferret		+	+
Neofelis nebuloa	Clouded leopard		+	+
Panthera leo	Lion		+	-
Panthera pardus	Leopard		+	+
Panthera tigris	Tiger		+	+/-
Vulpes spp.	Fox	+		+
Order: Cetartiodactyla				
Bos taurus	Cow		+	-
Order: Lagomorpha				
Ochotona curzoniae	Plateau pika	+		?
Oryctolagus cuniculus	New Zealand white rabbit		+	-
Order: Perissodactyla				
Equs africanus asinus	Donkey		+	-
Order: Primates				
Homo sapiens	Human		+	+
Macaca fascicularis	Cynomolgus macques		+	-
Macaca mulatta	Rhesus macques		+	-
Order: Rodentia				
Mus musculus	Mice		+	+
Rattus norvegicus	Brown rat		+	-

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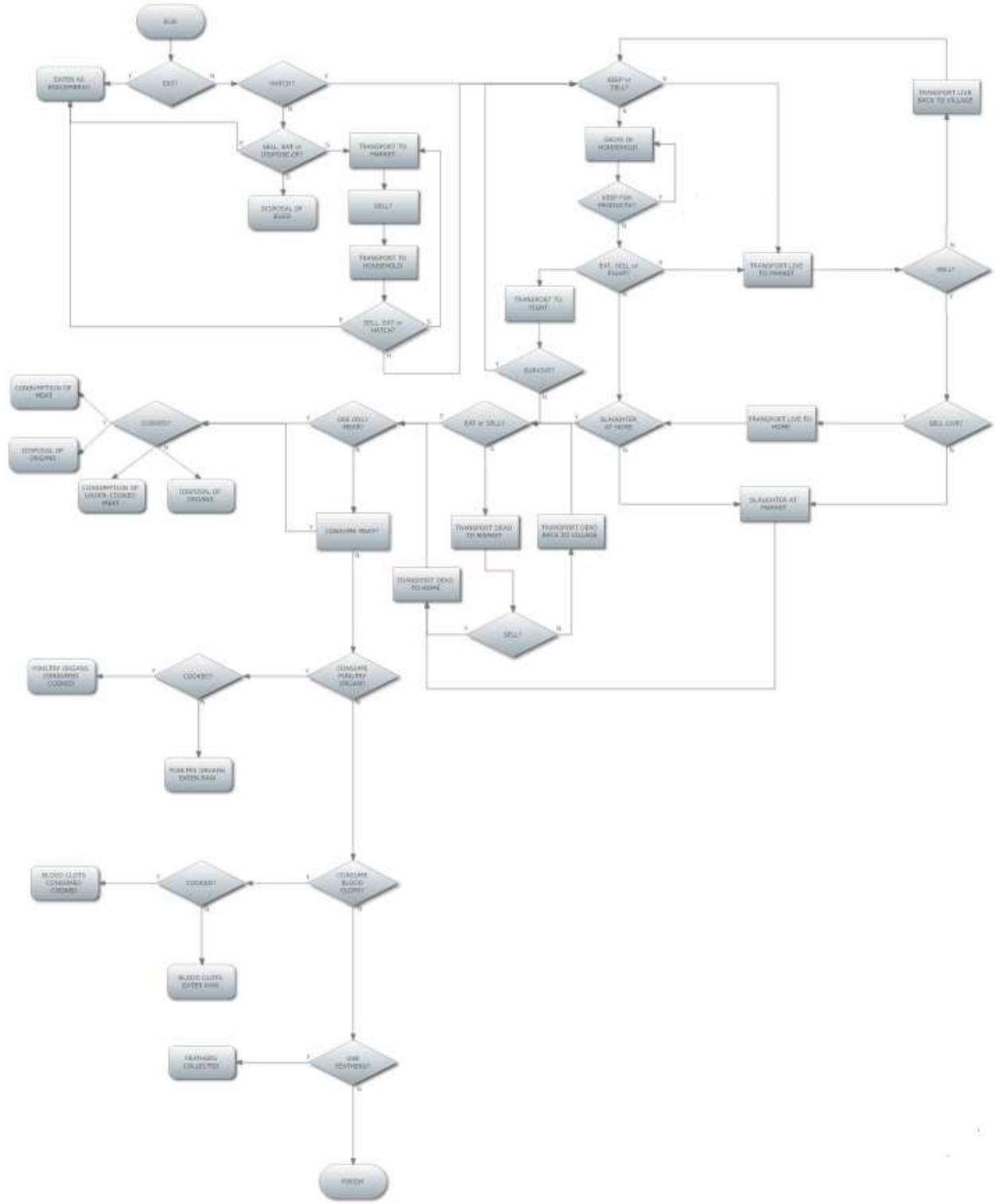

APPENDIX B Flowchart used during the hazard analysis of critical control points assessment conducted for the domestic poultry trade within Vietnam.

APPENDIX C The number of individuals for the 68 species recorded during surveys of wild bird markets across Vietnam. * - indicates that HPAI H5N1 infection has been reported for that species. *Italics* denote a species that is unique to the markets in that area. The IUCN status of each species is shown and represent LC-Least Concern, NT-Neat Threatened and VU-Vulnerable (IUCN 2010).

		MARKET								
		IUCN status	**Hanoi (Nov)**	**Hanoi (Dec)**	**Hanoi (Jan)**	**Hanoi (Feb)**	**HCMC**	**Hue**	**Tinh Gia**	**Da Nang**
NUMBER OF SHOPS / **SPECIES**			**34**	**33**	**37**	**34**	**9**	**7**	**14**	**2**
COLUMBIFORMES										
Barbary Dove	*Streptopelia roseogrisea*	LC	*16*	*6*	*35*	*428*				
Emerald Dove	*Chalcophaps indica*	LC							*1*	
Eurasian Collared Dove	*Streptopelia decaocto*	LC	*14*	*8*	*9*					
Spotted Dove	*Streptopelia chinensis*	LC	315	332	363	515	9	8	60	8
CORACIIFORMES										
Dollarbird	*Eurystomus orientalis*	LC	*1*							
CUCULIFORMES										
Asian Koel	*Eudynamys scolopacea*	LC	*1*							
Greater Coucal	*Centropus sinensis*	LC				*3*				
FALCONIFORMES										

Black Baza	*Aviceda leuphotes*	LC							*1*	
GALLIFORMES										
Common Pheasant	*Phasianus colchicus*	LC	*8*							
PASSERIFORMES										
Baya Weaver	*Ploceus phillipinus*	LC	*2*		*2*	*3*				
Black Bulbul	*Hypsipetes leucocephalus*	LC	*18*							
Black-collared Starling*	*Sturnus nigricollis*	LC	10	6	4	3		1		
Blue Magpie	*Urocissa erythrorhynca*	LC	*1*	*2*	*6*	*2*				
Black-naped Oriole	*Oriouls chinensis*	LC	1						2	
Black-throated Laughingthrush	*Garrulax chinensis*	LC	381	463	389	338	41	40	90	8
Blue-winged Leafbird	*Chloropsis cochichinensis*	LC				*2*				
Blue-winged Minla	*Minla cyanouroptera*	LC	*1*							
Bushlark spp.	*Mirafra spp.*		1	3						2
Common Green Magpie	*Cissa chinensis*	LC				*1*				
Common Myna*	*Acridotheres tristis*	LC	45	17	7	2	12	1	5	2

Common Tailorbird	*Orthotomus sutorius*	LC					*15*			
Crested Myna*	*Acridotheres cristatellus*	LC	35	11	8	4		1	12	
Eurasian Tree Sparrow*	*Passer montanus*	LC	4		1	2	12			
Golden-fronted Leafbird	*Chloropsis aurifrons*	LC	*1*		*1*					
Great Tit	*Parus major*	LC	4	3		12	1			
Greater Necklaced Laughingthrush	*Garrulax pectoralis*	LC							*7*	
Hill Myna*	*Gracula religiosa*	LC	52	42	54	33	8	4		
Hwamei	*Garrulax canorus*	LC	357	724	720	722	17	6	5	3
Island Canary	*Serinus canaria*	LC	165	190	208	223	4	2		
Java Sparrow	*Padda oryzivora*	VU	1	1	1		10			
Leafbird spp.	*Chloropsis spp.*	LC	3		3		2			
Lesser Necklaced Laughingthrush	*Garrulax monilegur*	LC	3	8	7	38			40	
Light-vented Bulbul	*Pycnonotus sinensis*	LC			*1*					
Munia 3 spp.*(known for two of these spp.)	*Lonchura spp.*	LC	1753	2327	4337	3860	25			790

Oriental Magpie Robin*	*Copsychus saularis*	LC	69	118	94	142	65	18	3	1
Paddyfield Pipit	*Anthus rufulus*	LC	44	24	12	6	4	1	1	1
Phylloscopus warbler spp.	*Phylloscopus spp.*		4				1			
Pied Bushchat	*Saxicola caprata*	LC	1	1		2	5			
Red Avadavat	*Amandava amandava*	LC	29	36	27	8	10			
Red-billed Leiothrix*	*Leiothrix lutea*	LC	276	213	208	41		2		
Red-billed Starling*	*Sturnus sericeus*	LC	1	2					26	
Red-whiskered Bulbul*	*Pycnonotus jocosus*	LC	614	705	875	731	42	150		237
Rufous-cheeked Laughingthrush	*Garrulax castanotis*	LC							*3*	
Rufous-vented Laughingthrush	*Garrulax gularis*	LC		1				2		
Scarlet-backed Flowerpecker	*Dicaeum cruentatum*	LC					*5*			
Siberian Rubythroat	*Lusciana calliope*	LC	*2*							
Silver-eared Mesia*	*Leiothrix argentauris*	LC	*70*	*82*	*7*	*34*				
Stripe-throated Bulbul	*Pycnonotus finlaysoni*	LC								*1*

Vietnamese Greenfinch	*Carduelis monguilloti*	NT	1							
Vinous-breasted Starling	*Sturnus burmannicus*	LC						*1*		
White-crested Laughingthrush	*Garrulax leucolophus*	LC	1	5	4	1	10	1	23	
White-eye 2 spp.*	*Zosterops spp.*		2527	1962	1200	1250	45	34	14	1
White-rumped Shama	*Copsychus malabaricus*	LC	51	167	56	51		27		
White-shouldered Starling	*Sturnus sinensis*	LC					10		78	
White-vented Myna*	*Acridotheres grandis*	LC				2			2	
Zebra finch*	*Taeniopygia guttata*	LC	*2*	*5*	*5*	*3*				
PICIFORMES										
Blue-throated Barbet	*Megelaima asiatica*	LC	*1*	*1*	*1*	*1*				
PSITTACIFORMES										
Alexandrine Parakeet	*Psittacula eupatria*	LC		1	1	3	1			
Blossom-headed Parakeet	*Psittacula roseate*	LC					*3*			
Budgerigar*	*Melopsittacus undulatus*	LC	634	315	179	348	146	23		5
Cockatiel	*Nymphicus hollandicus*	LC	*35*	*9*	*40*	*19*				

Fischer's Lovebird / Lovebirds spp.	*Agapornis spp.*	NT	92	68	69	82	5			
Grey-headed Parakeet	*Psittacula finschi*	LC				21	6		9	
Red-breasted Parakeet	*Psittacula alexandri*	LC	122	37	169	81	38	1	7	
TOTAL SPECIES			**47**	**35**	**35**	**37**	**28**	**18**	**21**	**12**
TOTAL INDIVIDUALS			**7769**	**7907**	**9117**	**9017**	**567**	**321**	**395**	**1059**

IUCN. 2010. Iucn Red List of ThreateNED Species. Version 2010.4. Available: http://www.iucnredlist.org [accessed October 27, 2010]

APPENDIX D Example of the questions asked during semi-structured interviews with wild bird vendors across Vietnam's urban centres during surveys conducted in November 2008 to February 2009.

MARKET INTERVIEWS

Interview date: **Market:** **Shop #:**

Interviewee age: **Gender:**

QUESTIONS

1. How long have you been selling live birds?
2. Which are the 5 most popular species? Does this change throughout the year?
3. Why are these species preferred?
4. Which species are the most profitable? Is this always the same?
5. What are the main reasons why people buy birds?
6. Is there a large supply of birds for you to buy for your shop?
7. Do you breed any birds yourself?
8. Where do the birds you sell come from? Are they from close to the city or another province?
9. Are the birds you sell captive-bred (farmed) or wild-caught?
10. Is selling birds your household's primary source of income?
11. How is the trade in birds now compared to other years?
12. When there is little demand for birds, how do you replace the lost income?
13. Have you ever had to stop selling birds? Why?
14. Are there any shops which used to sell birds but no longer do? Do you know why they stopped selling birds? What do they now sell?
15. Have there been any confiscations of birds from this market? Who by? What did they confiscate? When? Why?
16. Have the health department bought any of your birds?
17. How has your business been affected by bird flu?
18. How long did bird flu affect your business?
19. Do you perceive yourself to be at risk from bird flu?

20. Do you take any precautions to prevent the transmission of bird flu to yourself or your birds?
21. Are there any regulations regarding the birds which you can sell? Are any species restricted/prohibited to sell?
22. Were there any laws introduced to try and control bird flu?
23. Do any of your customers buy birds to take overseas?

APPENDIX E Sample of the questionnaire used during semi-structured interviews conducted with central Hanoi households. The data from these interviews were used for chapters 4 and 7.

Interview date: **Interview #:**

Age group: **Gender:** **Level of education:**

Occupation: **Household size:**

INTRODUCTION

Thank you for accepting our invitation to participate in this important research project. Our research project aims to understand how avian influenza has affected the diet and lifestyle of Vietnamese people in recent years. The interview should take about 20 minutes. We will use strict confidentiality when handling information from the interview.

We will not collect any data which can identify you or your answers. The questions concern primarily your own experiences and those of your household. It is faster if I record the interview as I won't lose any information while I take notes. Do you mind me using a tape recorder?

FOODS

1- Which types of meat are the most important for your household? *(let them give their answers and then ask them if they eat the following – chicken, duck, wild meat)* Has this changed in the last 3 years?
2- How many kgs of poultry does your household eat/week? How many eggs/week?
3- How has the price of poultry and eggs changed in the last 3 years? What do you think has caused this?

4- At what time of year, do you buy the most poultry? How does the price of poultry at that time compare to other times?
5- Where do you usually buy poultry (in the supermarket or in the market)? Have you always bought it there? Why?
6- Which kind of chickens do you usually buy?
    - Farmed chickens or free-range?
    - Live or slaughtered chickens?
7- Do you ever slaughter or pluck poultry in your household?
8- Do you consume poultry organs in your household?
9- Do you eat blood clots (tiet canh) from poultry? Why?

KEEPING ORNAMENTAL BIRDS

10- Does your household keep any live birds?

If **Yes**:

11- Which species and why these species?
12- How long have you kept birds?
13- Have you ever been concerned that your birds may carry diseases such as bird flu?

If **No**:

14- Have you ever kept birds? Which kinds of birds?
15- Why did you stop keeping birds? *(give them the chance to answer for themselves before asking the next question)* Did bird flu influence your decision?

RELIGIOUS MERIT RELEASE

16- Does anyone in your household participate in religious merit release?

If **Yes:**

17- Where do you go to for this?

18- How often / when do you participate in this?

19- Which animals do you release and where do you get them from?

20- What is the main reason for you to participate in this?

21- Have there ever been any changes to how you participate in RMR?

AVIAN FLU

22- How big a problem is bird flu? (*Don't help them with suggestions unless they don't understand the question)*

What animals can bird flu affect?

If they don't say humans, ask them if it can affect humans.

Do you know:

+ What causes bird flu? (*if they don't know, ask them if they know what H5N1 is)*

a. What species has it affected in Vietnam?
b. Is bird flu a threat to Vietnam's wild animals?
c. Which people have been most affected by bird flu?
d. Why were these people most affected and which area do they live in?
e. Does the government provide help for those people? If yes, how?

+ Species affected by bird flu. *Ask which of the following statements they think are true.*

f. Bird flu **only** transmits from poultry to poultry?
g. Bird flu **can** transmit from poultry to human?
h. Bird flu **can** transmit from human to human?
i. Bird flu **can** infect many species of wild birds as well as poultry?

j. Bird flu **can** infect many species of wild animals, not only birds?

k. People **always** die if they catch bird flu?

+ Which ways can bird flu transmit to humans? *Ask them which of the following statements they think are true.*

l. Direct contact with infected poultry/eggs?

m. Eating undercooked poultry meat/eggs?

n. Eating blood clots?

o. Slaughtering of poultry?

p. Plucking of poultry feathers?

q. Visiting markets where live poultry are sold?

r. Direct contact with an infected person?

s. Contact with poultry dung?

t. Through contact with contaminated materials such as soil, water, shoes, etc.?

23- Have you ever been concerned bird flu may affect your family's health?

24- Do you eat poultry and eggs when there is bird flu in VN? If yes, where do you eat/buy them?

25- How do you protect your household from avian flu?

(*If they do not know, give them the following options and ask them to arrange options from most necessary to least necessary based on their opinion*)

a. Avoid direct contact with poultry

b. Wash hands regularly

c. Use quarantined (approved) poultry

d. Do not eat poultry blood clots

e. Do not slaughter poultry in the home

f. Cook all poultry meat and eggs thoroughly before eating

g. Do not eat any poultry

26- Where does your household get information on disease outbreaks that are happening within Vietnam?

APPENDIX F Sample questions asked during semi-structured interviews conducted in rural Vietnamese households to collect data presented in chapters 5 and 6.

Date:

Village: Interview #:

HH size: HH wealth ranking:

POULTRY

How many poultry are kept by your household?

Why these particular animals?

(To confirm they've told us of all poultry) How many of the following animals do you keep in your household?

-Ducks

-Chickens

-Geese

-Other birds

Why are poultry important for your household?

-As a source of income?

-As a source of food?

-Other?

How long have you been keeping poultry?

Who is responsible for looking after the poultry?

What % of household income is from poultry?(Can give categories e.g. 10-20%, more than 25% if they are reluctant to answer initially)

How has the price of poultry changed in the last five years?

What has caused this?

How has the price of eggs changed in the last five years?

What has caused this?

PROTEIN

What is the most important protein source for your household (**USE PICTURE CARDS**)?

Is this your preferred source for protein?

How has this changed in the last five years (can **use cards** if necessary)?

Which species of wild meat do members of your household eat?

Where does this wild meat come from (do you buy or catch yourself?)

BIRD FLU

How big a problem is bird flu (ask this before prompting with the three options below if necessary)?

-Globally?

-For Vietnam?

-For your household?

How many bird flu outbreaks have occurred in your village?

When did these outbreaks occur?

How many birds died during these outbreaks?

Which animals were affected by these outbreaks?

-Poultry?

-Wild birds?

-Mammals?

How many households in your village have been affected by bird flu either directly to themselves or their poultry?

Has your household ever been affected by bird flu? If so, when? How many animals were affected? Which animals?

If it hasn't already, are you concerned bird flu will affect your household or your village?

Do you know who to contact if you suspect a bird flu outbreak?

Do you take any precautions to prevent the transmission of bird flu to your family and your poultry?