An assessment of the feasibility of a poultry tracing scheme for smallholders in Vietnam

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Submitted for publication: 8 July 2010
Accepted for publication: 19 May 2011

Summary

Tracing movements could assist the implementation of bio-containment measures during a disease outbreak. To evaluate the potential for implementing a tracing system for a poultry supply chain in northern Vietnam, a four-month longitudinal study was conducted to identify marketing practices associated with poultry traceability. Poultry sold in batches were traced between farms and markets, and their traceability was assessed upon market arrival. A total of 315 batches were released from the farms; 37% arrived at a market, from which 57.3% were 'traceable'. The results of the multivariable analysis showed that traceability was associated with farms operating through no more than two traders (Odds ratio [OR] = 5.97, 95% CI 1.15–30.92) and batches brought to the market on the day of purchase (OR = 4.05, 95% CI 1.23–13.27). No specific incentives were provided to farmers or traders. Results suggest that there is potential for implementing a poultry traceability scheme, although the tracing methodology should be refined.

Keywords

Animal movement – Avian influenza – Longitudinal study – Marketing practice – Poultry market – Poultry supply chain – Poultry trader – Traceability – Vietnam.

Introduction

Highly pathogenic avian influenza (HPAI) virus subtype H5N1 was first isolated in domestic poultry in Hong Kong in April 1997 (29), where the disease re-occurred in 2001 and 2002 (2). The virus caused severe disease and mortality in poultry and humans (8). Between December 2003 and February 2004, cases of HPAI H5N1 were identified in eight countries in South-East Asia (the Republic of Korea, Vietnam, Thailand, Cambodia, Laos, the People's Republic of China, Japan and Indonesia) (3). Vietnam reported its first case of HPAI H5N1 in poultry in December 2003 (11). The consequences of HPAI H5N1 in Vietnam have been very severe. From a public health perspective, Vietnam has one of the highest levels of confirmed cases (n = 119) and deaths (n = 59) in the world, with a case fatality rate of 49.6% (35). The disease-associated losses in the poultry population have been estimated to be approximately 50 million birds (17, 22).

In 2004 and 2005, outbreaks showed a cyclical temporal pattern with maximum incidence around the 'Tết' holiday festivities (Vietnamese New Year), when poultry production and trade intensifies (23). Although outbreaks were reported throughout the country, disease clustered in space in highly populated areas of the Mekong river delta and in the Red river delta around Ha Noi and Da Nang cities (19, 23). Since that early outbreak period, the spatial pattern of reported outbreaks has followed the same geographical distribution, but the temporal pattern is no longer regular, and it is believed that infection has become endemic in some parts of Vietnam (12).

The contact structure between individuals is known to have an important role in the incursion and spread of contagious diseases in both human and animal populations (15, 18, 21). In the case of avian influenza the movement of live birds is a known risk factor for the dissemination of the virus to poultry flocks (16). Few published studies have documented the relationship between smallholder poultry and trade and there has been little research into the interactions between smallholder farms, live poultry traders (LPTs) and live poultry markets (LPMs) in South-East Asian countries affected by HPAI H5N1. However, in Vietnam, a study of the geographical extent of the catchment areas of all authorised LPMs in the outer districts of Ha Noi found that LPTs are likely to play a role in HPAI H5N1 transmission (31).

The need to enhance control measures and to reduce disease risk in smallholder flocks was identified by international organisations (5) and the Vietnam government. It was also recognised after the first outbreaks that HPAI awareness at village level and biosecurity at farm level needed to be increased (9) and that the implementation of a poultry chain certification scheme would be beneficial (10). Additionally, it was recognised that higher food safety standards in smallholder poultry flocks could be achieved by using the demand side of the poultry market chain to create incentives for smallholder poultry farmers to improve product quality and safety (27).

The Codex Alimentarius defines traceability as 'the ability to follow the movement of a food through specified stage(s) of production, processing and distribution' (14). In the context of the poultry production system in Vietnam, traceability measures could be used to improve animal health and poultry product safety and to provide information to customers regarding the origin of live birds they purchase.

The objective of the present study was to assess the potential for establishing a poultry traceability scheme to track poultry between farms and LPMs within the catchment area of authorised LPMs. The study aimed to quantify the traceability of poultry from farms to LPMs and to investigate the association between poultry traceability and factors related to farm trade or to characteristics of the originating farm.

Materials and methods

Study area

The study area was located in the provinces of Ha Noi, Ha Nam and Ha Tay in northern Vietnam (Fig. 1). The area surrounding Ha Noi has experienced large numbers of HPAI H5N1 outbreaks since 2003 and is involved in intensive poultry production activity supplying the city through live poultry markets.

Study design, target population and unit of analysis

The study was conducted as a four-month longitudinal study between July and October 2008. The target population consisted of commercial smallholder poultry farms (100–2000 head) linked to LPMs in the outer districts of Ha Noi and the district of Ha Vi (Ha Tay province). Live poultry were purchased by traders at the farm gate, and placed into one or several baskets depending on the quantity purchased. The unit of analysis was a group (batch) of birds sold, on a specific day, by one farmer to one trader. Depending on the total number of birds, the batch would consist of one or several baskets for transport.

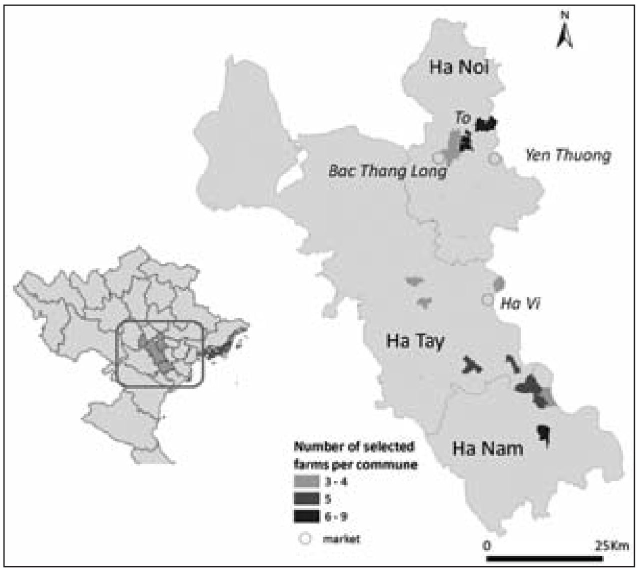

Fig. 1
Study area in northern Vietnam: location of communes with study farms and markets in the provinces of Ha Noi, Ha Tay and Ha Nam

Farm and market selection

The study farms and study markets for the present study were selected on the basis of the results of a previous study that described the farm gate trade patterns and catchment areas of the 11 most important LPMs supplying the province of Ha Noi (30). This study identified the four main markets of the area to be: Yen Thuong, To, Bac Thang Long and Ha Vi; consequently, these markets were also used in the present study. Most poultry traded through these 11 markets had been sourced from the poultry flocks of Ha Tay, Ha Nam and Ha Noi provinces. Within those provinces, districts that had communes which traded poultry through one of the four study markets were included in the present study. A district veterinarian (DV) visited poultry farmers owning flocks of between 100 and 2,000 head, explained the study, and sought their consent to participate in the study. The farms were what the Food and Agriculture Organization (FAO) would classify as 'Sector 3' farms. The FAO describes four categories of poultry farms based on their level of biosecurity and the destination of the birds they produce; they range from farms with high biosecurity producing birds for the commercial market (Sector 1) to farms with low biosecurity producing birds for local consumption (Sector 4) (13).

To be able to estimate the main outcome variable of interest, i.e. the percentage of poultry batches arriving at live bird markets in traceable condition, a sample size of 68 farms was considered, assuming an expected 15% traceability of poultry batches with a precision of +/– 9% at 95% confidence level (assuming one batch per farm and unlimited population size).

Data collection

Farm-level dataset

When a farm was included in the study, a DV administered a questionnaire to the farmer to collect data on farm characteristics and trade practices. Afterwards, each time farmers were about to sell poultry batches to traders, they notified the DV. The DV came on farm and conducted a visual health inspection of the poultry to be sold to traders. Healthy birds were released for sale and each was marked with a yellow plastic tag. The birds were then placed into one or several baskets, together comprising a batch. For each batch, data on farm identification number, batch weight and date of batch purchase were written in a single radio frequency identification (RFID) tag using a portable computer which also stored this information. The RFID tag was attached to one of the baskets from a batch. A total of fourteen DVs were involved.

The RFID tags were TROVANFLEX™ circular transponders (32), which are resistant to harsh environments and have a 12-digit number storage capacity. The information was written in and read from the RFID tag and could be downloaded to a computer using TROVAN UNIQUE™ portable reader devices (32).

Market-level dataset

In the study markets, all vehicles carrying poultry stopped at a checking point where market inspectors (MI) could check batches upon arrival. Market inspectors were trained to fill in a form containing the following batch information: name of the market, date of arrival and batch weight. They also noted whether or not all birds in the batch had a yellow plastic tag.

At both farm level and market level, industrial digital bench weighing scales were used, each with a maximum weighing capacity of 300 kg. Scales were calibrated at the beginning of the study by a technician from the supplying company.

Case definition

The main outcome of interest was whether all poultry comprising a batch arriving at an LPM were traceable. The assessment of the traceability status of a batch was based on two criteria: (i) a comparison of the weight of the batch at the farm gate and its weight on arriving at the market, and (ii) a search for untagged birds within the batch on arrival at market (all birds were tagged before being released from the farm). When the batch weight had not changed and, in addition, all poultry in the batch had a yellow plastic tag, then the poultry batch was defined as 'traceable'. Allowance was made for a weight variation of +/– 10% to account for circumstances that may slightly affect the batch weight, such as poultry dehydration during transport, wet baskets due to rain, or force-feeding practices on the way to the market. Using this case definition, batches which had a weight variation beyond +/–10% were classified as 'non-traceable', regardless of whether or not all the birds in the batch had a yellow plastic tag. Table I presents the classification of batches with regards to the two criteria used.

Table I
Classification of batches according to weight change and presence of untagged birds on arrival at market

Weight change	Presence of birds without yellow bird tag (%) No	Presence of birds without yellow bird tag (%) Yes	No. of batches arriving at market
≤10%	67 (91.8)	6 (8.2)	73
> 10%	29 (65.9)	15 (34.1)	44
Total	**96 (82)**	**21 (18)**	**117**

Data analysis

Descriptive statistics were generated at farm and batch level. Surveyed farms were described according to their production type, flock size and farm-gate trading practices. A description of batches released at the farm gate and arriving at a market was also provided. Statistical comparisons were conducted using non-parametric statistical methods.

Univariable and multivariable analyses were restricted to those batches which arrived at the study markets, and potential factors associated with traceable batches were examined. In the univariable analysis, odds ratios (ORs) with 95% confidence levels were used for categorical variables and Wilcoxon rank sum (WRS) tests for continuous variables. The multivariable analysis was a mixed-effect logistic regression model, with a batch as the unit of observation and its traceability status as the outcome. Variables that were significantly associated with the outcome in the univariable analysis at $p \leq 0.05$ were included as fixed effects in the multivariable analysis. To account for the dependence in the data resulting from methods of selecting farms and batches, commune and farm were included as random effects. A forward stepwise variable selection process was used for fixed effect variables, with both random effect variables forced into the model. Models were compared using analysis of deviance. The goodness-of-fit of the final model was assessed using the Pearson chi-squared statistic, by examining the residuals and calculating the dispersion parameter (34). The assumption that the residuals of the random effect follow a normal distribution was assessed by examining the plot of ordered residuals versus their normal scores (6). Data analysis was performed using the Software R-2.6.2 (25). The graphics were produced using the R package lattice (28), and the regression analysis was conducted using the R function 'glmer', from the R package lme4 (4).

Results

Descriptive statistics

Characteristics of study farms

All 68 selected farms were small-scale poultry production units: 50% raised fewer than 425 birds, and the biggest farm kept 2,000 birds. Among those farms, 57.4% (39) reared chickens, 30.8% (21) reared ducks, and 11.8% (8) raised chickens and ducks. Flock size was not associated with production type (Kruskal–Wallis [KW] test, $p = 0.148$).

All farms sold their poultry through traders, except one, which sold to traders and other farmers. Farmers reported selling to an average of 1.9 traders (sd = 1.4), with 50% of farms selling to only one trader (interquartile range [IQR] 1–2). The median number of traders per farm was higher in mixed farms than chicken farms (WRS test, Bonferroni correction, $p = 0.02$). A third of farms (32.3%) always sold to the same trader(s), and this farmer/trader connection did not depend on the type of trader (Fisher's exact test, $p = 0.924$), or on production type (Fisher's exact test, $p = 0.1$). However, smaller farms (fewer than 500 birds) were more likely to change traders than farms with more than 500 birds (Fisher's exact test, $p = 0.01$).

Three types of traders were identified according to the volume of poultry they handled and their position in the poultry marketing chain: wholesalers, assemblers and retailers. Almost all farms (95.3%) reported that they sold only to one type of trader; most farms traded through wholesalers (53.1%) and assemblers (32.8%). The proportion of chicken farms and mixed farms (chicken and duck) trading through wholesalers (63.2% and 77.8%) was significantly higher than the proportion of duck farms that traded this way (21%) (Fisher's exact test, Bonferroni correction, $p = 0.01$ and 0.03). Most duck farms (63.2%) said that they sold their production to assemblers.

Poultry batches released at the farm gate

During the farm visits, a total of 315 batches of poultry were recorded as having been released from 64 of the 68 selected farms (four farms did not record any batch release). Of these 315 batches, 31 duplicates of the 12-digit RFID numbers were detected, with one farm alone (farm 36) releasing 32 batches showing 15 duplicated numbers. All records were kept in the data analysis, and reasons for this are developed in the discussion section.

Half of the farms released four batches or fewer (IQR 1–6). The number of batches released per farm did not depend on farm size (Spearman correlation coefficient [Scc] $\rho = 0.08$, $p = 0.5$), production type (KW test, $p = 0.727$) or number of traders per farm (Scc $\rho = 0.09$, $p > 0.4$). Half of the batches released weighed 210 kg or less (IQR 150–270.8) (Table II). Batch weight was positively correlated with farm size (Scc $\rho = 0.204$, $p < 0.001$) and

Table II
Number of farms classified according to average weight of batch of poultry birds at farm gate

Mean batch weight (kg)	Number of farms (%)	
<200	28	(43.8)
200–300	20	(31.3)
301–500	11	(17.2)
>500	5	(7.8)
Total no. of farms	**64**	**(100)**

batches were heavier in chicken or duck farms than in mixed farms (WRS test, Bonferroni correction, $p < 0.001$ for both).

Poultry batches arriving at the study markets vs lost batches

A total of 117 batches were reported to have arrived at one of the four markets. Six of these batches were not reported to have been released at the farm gate. Of the initial 315 batches released from the farms, 35.2% (111) were recorded as arriving at a market and 64.8% (204) were lost (Fig. 2). Batches arriving at the markets originated from 48 of the 64 releasing farms. The proportion per farm of batches arriving at a market was not associated with the number of traders per farm (Scc $\rho = 0.14$, $p = 0.26$), or with the farm size (Scc $\rho = -0.13$, $p = 0.32$), or with whether or not the same trader was used each time (WRS test, $p = 0.514$). However, duck farms, mainly dealing through assemblers, had a higher proportion of batches (72.8%) arriving at a market than either chicken farms (37.8%) or mixed farms (25%) (WRS test, Bonferroni correction, *p*-values 0.001 and 0.038, respectively).

Traceability status of poultry batches on market arrival

Amongst the 117 batches arriving at a market, 57.3% (67) were traceable (Fig. 2). The percentage of traceable batches stratified by market is presented in Table III. A weight loss was recorded for 74% of non-traceable batches (Table IV).

Table III
Number of traceable poultry batches, stratified by market

Market	Number of traceable batches (%)	Total number of batches arriving
To	8 (88.9)	9
Bac Thang Long	13 (61.9)	21
Ha Vi	46 (52.9)	87
Yen Thuong	0 (0)	0
Total	**67 (57.3)**	**117**

Also, of the batches having a weight change ≤10%, only 8.2% had birds without an individual tag (Table I).

Batch variation in weight was divided by the farm gate weight, so that the batch weight at the farm gate could be plotted against the percentage of batch weight change between farm and market (Fig. 3). Figure 3 reveals interesting patterns of weight variation, e.g. one of the batches lightest at the farm gate increased its weight by over 200%, non-traceable batches heaviest at the farm gate (over 400 kg) generally had a percentage decrease of weight of over 30%, and one of the heaviest batches at the farm gate (weighed 863 kg) lost 80% of its weight, down to 168 kg.

Finally, the average batch travel time between farm and market was 4.2 days, with 75% of batches arriving at the

Table IV
Cross-classification of the poultry batch traceability status against their weight difference category

Batch traceability	Weight difference (market weight – farm weight): <–100 kg	–100 kg to 0 kg	+1 kg to 100 kg	>100 kg	Total
Traceable	0 (0%)	61 (91%)	6 (9%)	0 (0%)	67 (100%)
Non-traceable	6 (12%)	31 (62%)	11 (22%)	2 (4%)	50 (100%)

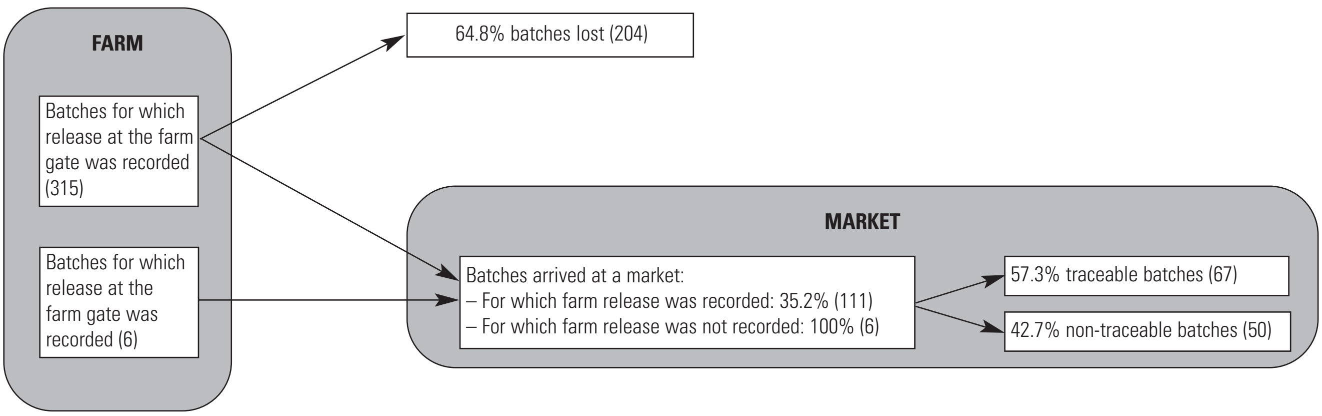

Fig. 2
Flow diagram representing the batches released at the farm, the batches lost and the batches that arrived at the markets

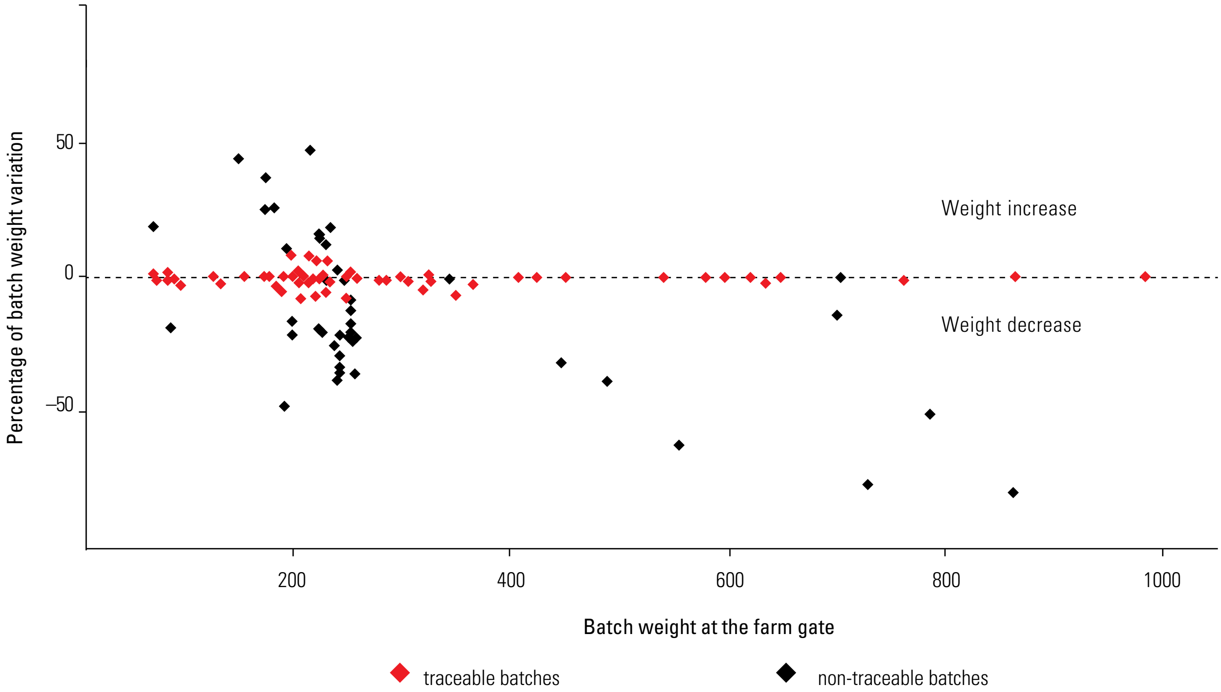

Fig. 3
Batch weight at the farm gate against percentage of batch weight variation (market weight – farm weight)
The dashed line represents zero percentage variation. Dots above the dashed line represent the batches for which an increase of weight was reported between farm and market whilst dots below represent the batches for which a weight decrease was recorded

market on the day of purchase (IQR 0–1). The distribution of non-traceable and traceable batches is presented in Table V. Traceable batches had a lower median time of travel than non-traceable batches (one-sided WRS test, $p < 0.001$).

Univariable analysis

Five variables were found to be associated with batch traceability status: 'time to market', 'farm type', 'number of traders', 'type of trader' and 'use of same trader(s)'. A strong collinearity was observed between 'number of traders' and 'use of same trader(s)' (WRS test, $p < 0.001$), so the latter was dropped from the multivariable analysis. Detailed results of the univariable analysis are presented in Table VI.

Table V
Descriptive statistics of the distribution of travel days between farm and market for traceable and non-traceable batches

Batch traceability	Number of travel days				
	Min.	1st Quartile	Median	3rd Quartile	Max.
Traceable	0	0	0	1	37
Non-traceable	0	1	1	2	98

Multivariable analysis

The model with the best fit to the data (Pearson chi-squared statistic, $p = 0.991$, $\varphi = 1.02$) contained as fixed effects 'number of traders' and 'days to market' as categorical-scale variables (Table VII), and 'commune' and 'farm identification number' as random effects. A batch originating from farms trading with one or two traders had 5.97 (95% CI 1.15–30.92) times the odds of being traceable compared with a batch from a farm trading with more than two traders. Batches delivered to the market on the same day were more likely to have fully traceable content than batches which were delivered later (OR = 4.05; 95% CI 1.23–13.27). The interaction effect could not be tested in the multivariable analysis, as the model did not converge, probably due to a small number of observations in some categories. Interaction was therefore assessed using stratified analysis, as shown in Table VIII. The crude OR for the association between batch traceability status and categorised 'number of traders' was 8.33 (95% CI 3.6–20). Confidence intervals of the OR values following stratification overlapped between the two strata defined by 'days to market' (Table VIII), suggesting little evidence of an interaction.

Table VI
Results of the univariable analysis of the association between poultry batch traceability status and farm, batch or market characteristics

Variables	Categorical-scale variables: Odds ratio (95% CI)	For continuous-scaled variables: Wilcoxon rank sum test	*p*-value
Characteristics of source farms			
Poultry species			
– Chicken	1	n/a	n/a
– Duck	0.36 (0.16–0.77)	n/a	0.008
– Duck and Chicken	0 (0 – NaN)	n/a	0.107
– Flock size	n/a	Two-sided Wilcoxon	0.1729
Farm gate trade characteristics			
Number of traders per farm	n/a	Two-sided Wilcoxon	< 0.001
		One-sided Wilcoxon '1' less than '0'	< 0.001
Type of trader			
– A	1	n/a	n/a
– R	2.17 (0.79–5.96)	n/a	0.142
– W	2.38 (0.96–5.94)	n/a	0.066
– A + R	6.50 (1.28–33.05)	n/a	0.016
– A + W	0 (0 – NaN)	n/a	0.574
Use of same trader(s)			
– Yes	1	n/a	n/a
– No	8.18 (3.46–19.34)	n/a	< 0.001
Batch characteristics			
Weight at farm	n/a	Two-sided Wilcoxon	0.1824
Weight at market	n/a	Two-sided Wilcoxon	0.1915
Days to market	n/a	Two-sided Wilcoxon	< 0.001
		One-sided Wilcoxon '1' less than '0'	< 0.001
Market of arrival			
Bac Thang Long	1	n/a	n/a
Ha Vi	0.69 (0.26–1.83)	n/a	0.470
To	4.92 (0.51–47.07)	n/a	0.169

n/a: not applicable
A: assembler
CI: confidence interval
NaN: not a number
R: retailer
W: wholesaler

Table VII
Results of multivariable analysis for fixed effect variables based on a binomial generalised linear mixed model with commune and farm as random effects and traceability status of poultry batch as outcome

Variable	Estimate	Standard error	*p*-value	OR	95% CI
Number of traders					
>2	Ref.	n/a	n/a	1	n/a
1–2	1.7869	0.8390	0.033	5.97	1.15–30.92
Days to market					
>1 day	Ref.	n/a	n/a	1	n/a
Same day	1.3981	0.6057	0.021	4.05	1.23–13.27

CI: confidence interval
OR: odds ratio
n/a: not applicable

Table VIII
Cross-classification of poultry batch traceability status against categorised 'number of traders', stratified by categorised 'days to market'

Days to market	No. of traders	Batch traceability status		Total	Proportion of traceable batches	Stratum-specific odds ratios (95% CI)
		Traceable	Non-traceable			
Same day	1–2	47	7	54	0.87	24.4
	>2	0[1]	4	4	0	(2.1–1,336)
>1 day	1–2	13	16	29	0.45	2.7
	>2	7	23	30	0.23	(0.9–8.2)

1 due to zero count, 1 was included to allow odds ratio calculations

Discussion

As far as the authors are aware, this study represents the first investigation of the traceability characteristics of poultry traded between smallholder farms and live poultry markets in Vietnam.

The 68 farms selected for this study from the vicinity of Ha Noi were all small-scale poultry producers, raising chickens (57.4%), ducks (30.8%) or both (11.8%). Poultry batch traceability was associated with trader-related factors, but not with poultry species or flock size. Poultry batches were more likely to be traceable if farms sold their live poultry through only one or two traders rather than more than two, and traceability was also more likely if the batch arrived at the market on the day of purchase at the farm gate.

Some farmers traded through up to six traders and therefore would be at increased risk of introducing HPAI H5N1 virus onto their farms and spreading it to others. Mixed farms operated with more traders than chicken farms. Smallholder specialisation could lead to the potential establishment of links with specific traders, and farms raising different species might be more likely to be visited by an increased number of traders compared to those farms raising a single species, since the respective farms would be operating several production cycles in parallel.

A recent study in the same geographical area as the present study showed that traders working for less than a year and visiting authorised LPMs have increased odds of sourcing poultry from flocks, compared with traders who have traded for more than a year in wholesale markets (31). In the present study, the traceability status was not associated with the market of arrival, but 74% of batches (*n* = 87) arrived at the wholesale market of Ha Vi, which is not a newly established LPM. Additionally, most non-traceable batches were characterised by having lost weight. This effect could be the result of poultry being sold by traders or having died before reaching the market. While it is well recognised that LPMs represent a risk for HPAI H5N1 virus spread by allowing mixing of birds from multiple sources and between species (7, 16, 20), the events in the poultry supply chain between farm gate and the market have not been described previously for Vietnam. In this respect, the results of this study suggest that many traders do not take batches collected from a farm directly to a live poultry market, but rather sell or collect further birds on the way to the market. Their trading behaviour therefore represents a significant risk for HPAI H5N1 virus spread in the outer districts of Ha Noi. Recently, the role of trade in the spread of avian influenza was also emphasised in Nigeria, where proximity to a highway network increased the risk of disease occurrence (26).

A number of study limitations should be noted. Firstly, 64.8% of released poultry batches were lost to follow up. There are many possible explanations for what might have happened to them, including that their arrival at one of the study markets could have been missed or that they were taken to a market that was not included in the study. It also appeared that duck farms, mainly trading with assemblers in this dataset, had a higher proportion of batches arriving at a study market compared with mixed or chicken farms. Secondly, issues regarding the recording of batches should be considered carefully. Duplicates of the 12-digit number were detected in the farm release dataset. These either could have been distinct batches originating from the same farm, on the same day and having the same weight, or they could have been actual duplicate records. It was decided to keep all records for the following reasons:

– the field team was convinced that the batches with the same RFID tag number represented different batches

– amongst the market records two of the 12-digit numbers occurred twice, and the corresponding batches consisted of slightly different bird numbers, suggesting that they represented different batches.

Also, the authors might have underestimated the number of batches released, since six tagged batches arriving at a market and originating from five different farms were not found in the farm gate batches release dataset, probably due to a misuse of the portable computers. In that context, in which little inference in terms of batch traceability could be made in relation to the lost batches, and for which a number of uncertainties made it impossible to clearly link the farm dataset with the market dataset, the analysis of traceability was restricted to those batches arriving at the study markets only.

Potential biases were also introduced whilst selecting LPMs and poultry farms. When the authors carried out the surveys, LPMs in the inner districts of Ha Noi were not allowed to trade poultry anymore, and only LPMs in the outer districts of the capital city were allowed to do so. Additionally, the difficult implementation of the field work due to the high-technology equipment discouraged some farmers who were involved at the beginning and DVs had to replace those farms with farms from the same commune or district. Nevertheless, the market and farm selection were based on their importance with respect to the size of poultry production and trade; and on a history of recurrent HPAI H5N1 outbreaks in poultry in these areas (30).

Trading patterns can also vary between seasons of the year and across different years. Factors such as seasonal patterns of poultry demand related to 'Têt' festivities or the link between poultry production and seasonal agricultural activities can influence marketing patterns (20, 24, 33). In this area, trade has experienced changes following the implementation of HPAI H5N1 control measures that are similar to the measures applied in Hong Kong LPMs after 1997, e.g. market bans and restriction of marketing for certain poultry species (1, 29). However, the authors conducted their survey during a period when the poultry farms and markets were fully operational and, therefore, they believe that they worked in a context in which poultry flows between farms and markets reflected the trading activity of the area fairly well.

With respect to the tracing methodology used in this pilot study, it became clear during the planning phase that the tracing of individual birds was impractical. Instead, the tracing of groups of birds (i.e. batches) sold to a particular trader on a specific day and transported using one or several baskets appeared to be a more sensible approach. The status of the batch arriving at a live poultry market was checked using presence/absence of colour-tagged birds and a comparison of the weights at farm and market. Assuming accurate weight measurements, diligent search for untagged birds and accurate data recording, there should only be a low probability of batches being falsely classified as traceable.

The current study has shown that even in the absence of any specific incentives to farmers or traders, approximately 60% of the poultry can be traced back to the farm in this area of Vietnam. This surprisingly high proportion of traceable poultry provides an evidence base for the potential benefits of implementing a formal poultry traceability system. However, the implementation of the traceability approach tested in this study would constitute a major operational challenge given the complex structure of the poultry supply chain in Vietnam.

Acknowledgements

This study was supported by the Japanese Trust Fund, and implemented by the Food and Agriculture Organization of the United Nations in Vietnam. The authors are also grateful to the Department for International Development in the United Kingdom (UK) for partially funding this work through the HPAI Risk Reduction Project (GCP/INT/804/UK). The implementation of the field work was supported by staff from the Department of Animal Health (Ha Noi, Vietnam). The authors wish to thank Alexander Mastin for reviewing the results of the analysis. Royal Veterinary College (London, UK) Manuscript ID number: P/VCS/000145/.

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Évaluation de la faisabilité d'un plan de traçabilité appliqué aux petits producteurs de volailles au Vietnam

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Résumé

La traçabilité contribue utilement à mettre en œuvre des mesures de biosécurité suite à l'apparition d'un foyer. Une étude longitudinale a été conduite pendant quatre mois au nord du Vietnam afin d'évaluer les capacités de la filière aviaire à mettre en œuvre un système de traçabilité. Pour ce faire, l'étude a examiné les pratiques commerciales associées avec la traçabilité des volailles. L'origine des volailles vendues par lots à été retracée depuis les fermes jusqu'aux marchés et leur traçabilité a été évaluée à leur arrivée sur les marchés. Pendant la période étudiée, 315 lots ont quitté les fermes ; 37 % de ces lots ont été mis en vente sur les marchés, et leur origine a pu être retracée pour 57,3 % d'entre eux. Les résultats d'une analyse statistique ont montré une association entre la traçabilité des volailles, et d'une part, le fait que les exploitations travaillaient avec deux négociants ou moins (odds ratio [OR] de 5,97 avec un intervalle de confiance [IC] à 95 % compris entre 1,15 et 30,92), et d'autre part que les lots arrivaient sur le marché le jour même de l'achat (OR de 4,05 avec un IC à 95 % compris entre 1,23 et 13,27). Aucune incitation particulière n'a été prévue à l'intention des éleveurs ou des négociants durant cette étude. Au vu de ces résultats, la mise en œuvre d'un plan de traçabilité pour les volailles semblerait réalisable, mais il conviendrait de réviser la méthodologie utilisée à cette fin.

Mots-clés

Étude longitudinale – Filière aviaire – Influenza aviaire – Marché de volailles – Mouvement d'animaux – Négociant de volailles – Pratique commerciale – Traçabilité – Vietnam.

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Evaluación de la viabilidad de un sistema de rastreo de aves de corral de pequeñas explotaciones en Vietnam

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Resumen

El rastreo de los desplazamientos de los animales puede ser de ayuda para aplicar medidas de contención biológica en el curso de un brote infeccioso. Los autores describen un estudio longitudinal de cuatro meses encaminado a determinar las prácticas de comercialización que favorecen la rastreabilidad de las aves de corral, con la idea de evaluar las posibilidades de instituir un sistema de rastreo en la cadena de suministro aviar en el norte de Vietnam. Previo rastreo del transporte entre la explotación y el mercado de aves vendidas por lotes, se evalúo el grado de rastreabilidad a la llegada de las aves al mercado.

De un total de 315 lotes salidos de las granjas, un 37% acabó en un mercado, y de ellos un 57,3% eran 'rastreables'. Los resultados del análisis multifactorial pusieron de relieve que la rastreabilidad venía asociada a granjas que operaban a través de dos intermediarios como máximo (razón de probabilidades [OR] = 5,97, IC 95%: 1,15–30,92) y a lotes transportados al mercado el mismo día de la compra (OR = 4,05, IC 95%: 1,23–13,27). No se ofrecieron incentivos particulares a productores e intermediarios. De los resultados se deduce que hay posibilidades de instituir un sistema de rastreabilidad de las aves de corral, aunque habría que perfeccionar el método de rastreo.

Palabras clave
Cadena de suministro de aves de corral – Desplazamientos de los animales – Estudio longitudinal – Influenza aviar – Intermediario en aves de corral – Mercado aviar – Prácticas de comercialización – Rastreabilidad – Vietnam.

References

1. Agrifood Consulting International (2007). – The economic impact of highly pathogenic avian influenza: related biosecurity policies on the Vietnamese poultry sector. Prepared for the Food and Agriculture Organization of the United Nations and the World Health Organization. Agrifood Consulting International, Bethesda, Maryland, 74.

2. Alexander D.J. (2003). – Report on avian influenza in the Eastern Hemisphere during 1997–2002. *Avian Dis.*, **47** (3 Suppl.), 792–797.

3. Alexander D.J. (2007). – Summary of avian influenza activity in Europe, Asia, Africa, and Australasia, 2002–2006. *Avian Dis.*, **51** (1 Suppl.), 161–166.

4. Bates D., Maechler M. & Dai B. (2008). – lme4: Linear mixed-effects models using S4 classes. R package version 0.999375-18. Available at: lme4.r-forge.r-project.org/.

5. Bowman J.E., Gautier P. & Smith D. (2009). – STOP AI supports traditional poultry production to fight avian flu. Developments: DAI Newsletter, Summer 2009. DAI, Bethesda, Maryland, 9–11.

6. Brown H. & Prescott R. (2006). – Generalised linear mixed models. *In* Applied mixed models in medicine, 2nd Ed. Wiley, Chichester, 107–152.

7. Choi Y.K., Seo S.H., Kim J.A., Webby R.J. & Webster R.G. (2005). – Avian influenza viruses in Korean live poultry markets and their pathogenic potential. *Virology*, **332** (2), 529–537.

8. Claas E.C., Osterhaus A.D., van Beek R., de Jong. J.C., Rimmelzwaan G.F., Senne D.A., Krauss S., Shortridge K.F. & Webster R.G. (1998). – Human influenza A H5N1 virus related to a highly pathogenic avian influenza virus. *Lancet*, **351** (9101), 472–477.

9. Cristalli A. & Capua I. (2007). – Practical problems in controlling H5N1 high pathogenicity avian influenza at village level in Vietnam and introduction of biosecurity measures. *Avian Dis.*, **51** (1 Suppl.), 461–462.

10. D'Andlau G., Cardinale E., Gautier P. & Porphyre V. (2004). – Mission d'appui grippe aviaire au Vietnam. Fonctionnement de la filière et des systèmes de suivi épidémiologique : diagnostic et propositions d'amélioration. Rapport de mission. Agence Française de Développement, Ha Noi.

11. Delquiny T., Edan M., N'Guyen D.H., Pham T.K. & Gautier P. (2004). – Evolution and impact of avian influenza epidemic and description of the avian production in Vietnam. Food and Agriculture Organization of the United Nations, Rome, 119.

12. Dung Nguyen T., Vinh Nguyen T., Vijaykrishna D., Webster R.G., Guan Y., Malik Peiris J.S. & Smith G.J. (2008). – Multiple sublineages of influenza A virus (H5N1), Vietnam, 2005–2007. *Emerg. infect. Dis.*, **14**, 632–636.

13. Food and Agriculture Organization of the United Nations (FAO) (2004). – FAO Recommendations on the prevention, control and eradication of highly pathogenic avian influenza in Asia. FAO Position Paper. FAO, Rome.

14. Food and Agriculture Organization of the United Nations (FAO) & World Health Organization (WHO) (2008). – Codex Alimentarius Commission Procedural Manual, 18th Ed. FAO, Rome.

15. Kiss I.Z., Green D.M. & Kao R.R. (2006). – The network of sheep movements within Great Britain: network properties and their implications for infectious disease spread. *J. roy. Soc., Interface*, **3** (10), 669–677.

16. Kung N.Y., Morris R.S., Perkins N.R., Sims L.D., Ellis T.M., Bissett L., Chow M., Shortridge K.F., Guan Y. & Peiris M.J. (2007). – Risk for infection with highly pathogenic influenza A virus (H5N1) in chickens, Hong Kong, 2002. *Emerg. infect. Dis.*, **13** (3), 412–418.

17. McLeod A., Morgan N., Prakash A. & Hinrichs J. (2005). – Economic and social impact of avian influenza. Emergency Centre for Transboundary Animal Diseases Operations, Food and Agriculture Organization of the United Nations, Rome.

18. Meyers L.A., Pourbohloul B., Newman M.E., Skowronski D.M. & Brunham R.C. (2005). – Network theory and SARS: predicting outbreak diversity. *J. theor. Biol.*, **232** (1), 71–81.

19. Minh P.Q., Morris R.S., Schauer B., Stevenson M., Benschop J., Nam H.V. & Jackson R. (2009). – Spatio-temporal epidemiology of highly pathogenic avian influenza outbreaks in the two deltas of Vietnam during 2003–2007. *Prev. vet. Med.*, **89** (1–2), 16–24.

20. Nguyen D.C., Uyeki T.M., Jadhao S., Maines T., Shaw M., Matsuoka Y., Smith C., Rowe T., Lu X., Hall H., Xu X., Balish A., Klimov A., Tumpey T.M., Swayne D.E., Huynh L.P., Nghiem H.K., Nguyen H.H., Hoang L.T., Cox N.J. & Katz J.M. (2005). – Isolation and characterization of avian influenza viruses, including highly pathogenic H5N1, from poultry in live bird markets in Hanoi, Vietnam, in 2001. *J. Virol.*, **79** (7), 4201–4212.

21. Ortiz-Pelaez A., Pfeiffer D.U., Soares-Magalhaes R.J. & Guitian F.J. (2006). – Use of social network analysis to characterize the pattern of animal movements in the initial phases of the 2001 foot and mouth disease (FMD) epidemic in the UK. *Prev. vet. Med.*, **76** (1–2), 40-55.

22. Otte J., Hinrichs J., Rushton J., Roland-Holst D. & Zilberman D. (2008). – Impacts of avian influenza virus on animal production in developing countries. *CAB Reviews: Perspect. Agric. vet. Sci. Nutr. nat. Resour.*, **3**, 080, 1–18.

23. Pfeiffer D.U., Minh P.Q., Martin V., Epprecht M. & Otte M.J. (2007). – An analysis of the spatial and temporal patterns of highly pathogenic avian influenza occurrence in Vietnam using national surveillance data. *Vet. J.*, **174** (2), 302–309.

24. Phan Huy L., Nguyen Quang N. & Nguyen Dinh L. (1997). – The country life in the Red River delta. Centre for Vietnamese and Intercultural Studies, Vietnam National University, Hanoi.

25. R Development Core Team (2008). – R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna. Available at: www.R-project.org.

26. Rivas A.L., Chowell G., Schwager S.J., Fasina F.O., Hoogesteijn A.L., Smith S.D., Bisschop S.P., Anderson K.L. & Hyman J.M. (2009). – Lessons from Nigeria: the role of roads in the geo-temporal progression of avian influenza (H5N1) virus. *Epidemiol. Infect.*, 1–7.

27. Roland-Holst D., Soares-Magalhaes R., Pfeiffer D.U., Do Huu D. & Otte J. (2006). – Pilot programme for certified smallholder poultry supply chains for Hanoi. Food and Agriculture Organization of the United Nations, Rome.

28. Sarkar D. (2008). – Lattice: lattice graphics. R package version 0.17-4. R Project for Statistical Computing. Available at: www.R-project.org.

29. Sims L.D., Ellis T.M., Liu K.K., Dyrting K., Wong H., Peiris M., Guan Y. & Shortridge K.F. (2003). – Avian influenza in Hong Kong 1997–2002. *Avian Dis.*, **47** (3 Suppl.), 832–838.

30. Soares Magalhaes R., Hoang Dinh Q. & Lan L.T.K. (2007). – Farm gate trade patterns and trade at live poultry markets supplying Ha Noi: results of a rapid rural appraisal. PPLPI Avian Influenza Research Report. Food and Agriculture Organization of the United Nations, Rome.

31. Soares Magalhaes R.J., Ortiz-Pelaez A., Lai Thi K.L., Hoang Dinh Q., Otte J. & Pfeiffer D.U. (2010). – Associations between attributes of live poultry trade and HPAI H5N1 outbreaks: a descriptive and network analysis study in northern Vietnam. *BMC vet. Res.*, **6** (1), 10.

32. Trovan (2009). – TROVAN Radio Frequency Identification (RFID) for animal identification, industry, logistics and access control. Available at: www.trovan.com.

33. Tung P.D. & Phong N. (2004). – Vietnam household living standard survey, 2002 and 2004. Basic information. Social and Environment Statistics Department, Vietnam General Statistics Office, Ha Noi.

34. Venables W.N. & Ripley B.D. (1999). – Generalized linear models. Modern applied statistics with S-PLUS. Springer-Verlag, New York, 211–240.

35. World Health Organization (WHO) (2010). – Cumulative number of confirmed human cases of avian influenza A/(H5N1) reported to WHO. Available at: www.who.int/csr/disease/avian_influenza/country/cases_table_2010_07_05/en/index.html (accessed on 8 July 2010).