Savannah Veterinary Journal

Original Research

Risk perceptions and preventive preparedness towards avian influenza (H5N1) at live bird markets in North-central Nigeria: Public health implications

*[a]Odetokun, I.A., [bc]Alhaji, N.B., [c]Isola, T.O., [b]Erena, A.A. and [b]Mohammed, B.

[a]Department of Veterinary Public Health and Preventive Medicine, University of Ilorin, Ilorin, Nigeria
[b]Avian Influenza Control Project Office, Niger State Ministry of Livestock and Fisheries Development, Minna, Nigeria
[c]Department of Veterinary Public Health and Preventive Medicine, University of Ibadan, Ibadan, Nigeria

ARTICLE INFO

Article history:

Received: October 11, 2017
Received in revised form: February 25, 2018
Accepted: February 27, 2018.

Keywords:

Biosecurity measures,
HPAI H5N1
Live bird markets
Poultry traders
Public health.

ABSTRACT

Introduction: Live bird markets (LBMs) provide optimal conditions for transfer of infections, evolution of infectious pathogens and their transmission among animals and humans.
Methods: A cross-sectional study was conducted on poultry traders between October 2015 and May 2016 to assess their knowledge/awareness and zoonotic risk perceptions about HPAI H5N1, and biosecurity practices against the disease at LBMs in North-central Nigeria.
Results: A total of 403 poultry traders: 261 bird vendors (67.8%) and 142 bird collectors (35.2%) with mean age of 42.3±12.3 years participated in the study. The majority of vendors (90.8%) and collectors (78.9%) reported that H5N1 outbreaks had occurred in Nigeria. Only 5.4% of vendors and 12.0% of collectors perceived handling of wild birds at markets to be of high zoonotic risk. Less than half of vendors (49.0%) and collectors (38.7%) practiced isolation of sick birds from the flocks as biosecurity measure. Vendors were less likely (OR: 0.58; 95% CI: 0.37-0.89) to possess satisfactory knowledge about HPAI H5N1 than the collectors. Poultry traders with tertiary education were more likely (OR: 5.81; 95% CI: 2.91-11.60) to practice satisfactory biosecurity measures against HPAI H5N1 than traders with no formal education.
Significance: Though most traders expressed appreciable epidemiological knowledge about HPAI H5N1, their levels of zoonotic risk perceptions and practices of biosecurity measures in the markets were suboptimal, posing public health challenges. Development of educational programmes and regulatory measures that will enhance poultry traders' awareness level and better biosecurity management of zoonotic risks prevention and control at LBMs is recommended.

Introduction

Highly pathogenic avian influenza (HPAI) H5N1 is an emerging and re-emerging zoonotic disease with significant economic, food security and human health implications (Brown *et al*., 2015). The wide genetic diversity of avian influenza viruses and the potential for recombination with human influenza strains continue to pose major public health challenges (Li *et al*., 2010; Fournié *et al*., 2011). Genetic reassortment of influenza viruses is more rapid in aberrant hosts, such as persons working or living with domesticated birds, because of adaptive co-infection in susceptible hosts and interspecies mingling, making them important potential sources of viral amplification and infection (Suarez *et al*., 2004; Webster, 2004).

Live bird markets (LBMs) are part of the food supply chain that provide both poultry meat and live birds, which are essential for maintenance of health and nutritional status of humans (Yee *et al*., 2008; Guan and Smith, 2013). However, LBMs also provide major contact points between humans and animals, and therefore provide optimal conditions for zoonotic transfer and evolution of infectious pathogens (Kung *et al*., 2003; Wan *et al*., 2011; Alhaji and Odetokun, 2013; Zhou *et al*., 2015). The presence of multiple host species and the continued introduction of naive birds create an ideal environment for the persistence and emergence of avian influenza viruses (Horm *et al*., 2016). Avian influenza surveillance programmes in several Asian and African countries have demonstrated that HPAI viruses circulate in LBMs (FAO, 2013). Contamination of LBMs environment with influenza viruses has been particularly associated with slaughter and poor disposal of birds' carcasses (Indriani *et al*., 2013). Biosecurity measures of cleaning and disinfecting equipment and vending areas are often inadequate at LBMs and ineffective biosecurity measures may also create conditions that favour silent spread of disease agents at these environments (Cardona *et al*., 2009; Yupiana *et al*., 2010; Alhaji and Odetokun, 2013; Naysmith, 2014; Fasanmi *et al*., 2017). Previous epidemics of HPAI H5N1 that occurred in Nigeria between 2006 and 2008 affected 67.6% (25/37) of states in the country, with destructions of about 160 million poultry a-

*Corresponding author Tel: +2348030886018
email addresses: odetokun.ia@unilorin.edu.ng

nd approximately US$ 5.4 million paid in compensation by the Government of Nigeria (Joannis *et al*., 2006; FAO, 2015; OIE, 2015). Following a recent global wave of HPAI H5N1 spread with newly affected countries, OIE confirmed the re-emergence of H5N1 HPAI in Nigeria in January 2015. In these renewed outbreaks; the disease spread to nearly 736 enterprises including LBMs and farms in 70.3% (26/37) states across the country (FAO, 2015; OIE, 2016). This event is particularly critical given the importance of the Nigerian poultry population to livelihoods and food security.

The control and prevention of infectious diseases depend heavily on compliance with recommended precautionary behaviour, and such compliance in turn depends on people's knowledge and level of perceived risk (De Zwart *et al*., 2007; Leppin and Aro, 2009). One reason people change their behaviour is when they perceived a threat to their health and livelihoods (Leppin and Aro, 2009). In Nigeria, adequate biosecurity at LBMs is a great challenge (Alhaji and Odetokun, 2013; FAO, 2015), but proper biosecurity is needed to control persistent circulation of avian influenza viruses and public health challenges at LBMs (Sims, 2012). Assessment of epidemiological knowledge about avian influenza (AI) among poultry traders within and outside LBMs is crucial because it has the potential to influence introduction and spread of HPAI viruses along the supply-marketing chain and preventive preparedness against zoonotic infections. This study was aimed at assessing poultry traders' knowledge/awareness and zoonotic risk perceptions about, and biosecurity practices against HPAI H5N1 at LBMs in North-central Nigeria.

Materials and methods

Study area and populations

The study was conducted in North-central Nigeria, comprising of six states and the Federal capital territory – Abuja. The zone was selected based on its central location, existence of LBMs and resurgences of HPAI H5N1 outbreaks status at the time of the study. Poultry supplies to the LBMs in the zone are mainly from commercial farms, backyard farms and scavenging village chickens. The study populations were classified either as a vendor or a collector based on the individual's socio-economic activity in the market. A collector (wholesaler) was defined as a trader that collects birds from all sectors of the poultry industry (farm or village) and transports them to markets; while a vendor (retailer) is a trader who primarily sells live poultry (chickens and ducks among others) from their temporary or permanent stalls directly to consumers at the market, and at LBMs' slaughter points.

Ethical approval

The study protocols for the survey were approved by the Niger State Ministry of Livestock and Fisheries Development, Minna Research Ethics Committee (ref. MLFD/NGS/677). Advocacy visits were made to each market by the research team a week prior to the proposed interview and the necessary permission obtained from market leaders.

Study design, sample size and sampling procedure

A questionnaire-based cross sectional study was conducted on poultry traders between October 2015 and May 2016. The sample size was calculated using the Open Source Epidemiologic Statistics for Public Health **(**OpenEpi) 2.3 software (Dean *et al*., 2009); with proportion of those who have better biosecurity practice set at 50% and 5% margin of error at 95% confidence level. A sample size of 384 was obtained. A 5% contingency was added to take care of non-response, and 403 participants were enrolled into the study. A total of 28 LBMs were purposively selected across the zone, with at least three from each of the six states and Abuja. From each LBM, 14 participants (vendors and collectors) were randomly selected. A systematic random sampling method – with sampling interval of two – was used to select the participating poultry traders.

Questionnaire design, pretesting and data collection

A structured questionnaire was designed with mostly close-ended questions, to ease data processing, minimise variation, and improve precision of responses. The questions elicited details of respondent's demographic and socio-economic characteristics of age, gender, socio-economic activities, formal education, and type of poultry trade activities; epidemiological knowledge about HPAI H5N1: clinical signs, zoonotic potential, routes of transmission, and associated predisposing risk factors at the LBMs; traders' perceptions about zoonotic risks of HPAI H5N1; and biosecurity measures practiced against the disease at LBMs.

The questionnaire was designed in English and translated verbally into local language of *Hausa* during the process of administering to the respondents who are illiterates. It was pre-tested prior to the study on traders in three of the LBMs and all identified mistakes in the designed questions were corrected. Trained enumerators (six) were recruited and they conducted the interviewer-administered questionnaires. Participants were informed about objectives of the study. Their informed consents were verbally obtained before questionnaire administration and were assured of voluntary participation, confidentiality of responses and the opportunity to withdraw at any time without prejudice.

Data management and statistical analysis

Participants' responses were summarised into Microsoft Excel 7 (Microsoft Corporation, Redmond, WA, USA) spreadsheets. Descriptive and analytical statistics were used to describe obtained data. In the descriptive analysis, frequency and proportion were used. Categorical variables were presented as proportions and the bivariate associations were determined by Chi-square tests. Associations of poultry traders' demographic and socio-economic characteristics with their levels of knowledge/awareness and biosecurity practices were first subjected to univariate analysis using Chi-square tests. All factors found to be statistically significant at univariate analysis were

subjected to the likelihood stepwise backward multivariable logistic regressions to control for confounding and test for effect modification. Independent (explanatory) variables were created from demographic and socio-economic characteristics of the respondents in the questionnaires while their levels of responses to overall knowledge and biosecurity measures practiced constituted the dependent (outcome) variables. To create outcome variables, a unique scoring system was used for the responses. Each respondent was assigned a response score within a range of 1 to 20 points and converted to 100%. The reliability score for the scale is 90%. These scores reflected stringency of their responses to questions. The score range was further categorised into 'poor' or 'satisfactory' as binary variables. Response scores within 1 to 10 points were considered 'poor' (≤ 49%) and those within 11 to 20 points were considered 'satisfactory' (≥ 50%).
The Hosmer and Lemeshow test was used to assess for goodness of fit of the final model and was found to be good. The OpenEpi 2.3 software (Dean *et al*., 2009) was used for statistical analyses. A p-value < 0.05 was considered statistically significant in all the analyses.

Results

Demographic and socio-economic background and LBMs activities

All the 403 poultry traders: 261 bird vendors (67.8%) and 142 bird collectors (35.2%) participated in the study. Mean age of the respondents was 42.3 ± 12.3 years. The majority (80.4%) of the respondents were males, and more than half (56.3%) were married. The majority (34.5%) of the poultry traders had primary level of education, while 25.5% and 15.9% had secondary and tertiary educational levels, respectively. But 24.1% of the traders had no formal education.
On socio-economic activities, 46.4%, 26.4%, 10.7% and 16.5% of the vendors traded in chickens, ducks, wild birds, and mixed species of domestic birds, respectively. Less than half (47.2%) of collectors traded in chickens, 24.7% on ducks, 7.7% on wild birds, and 20.4% traded in mixed species of domestic birds (Figure 1). The majority (47.4%) of the traders kept their birds in corrugated zinc shops, while 40.4% and 12.2% of them kept theirs in open spaces and cement block shops, respectively. Most (58.8%) of the traders transported their birds to and fro LBMs by Lorries, 20.1% by cars, 14.4% by motor-bikes, 7.7% by bicycles, and 3.0% by trekking on foot. All the respondents mentioned that poultry business have socio-economic impacts on their livelihoods.

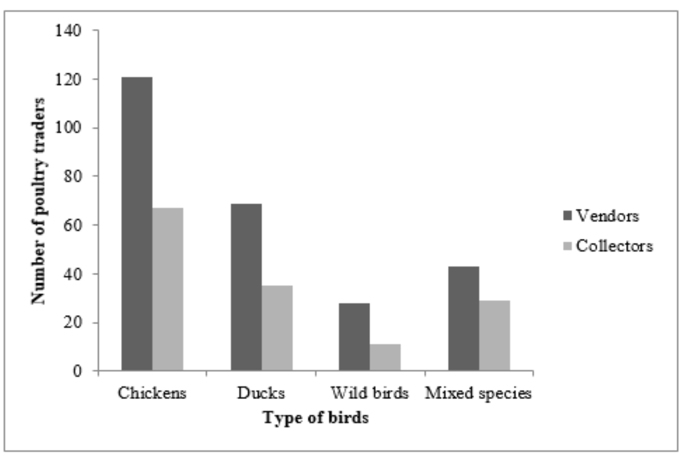

Figure 1. Distribution of birds traded by poultry traders at live bird markets in North-central Nigeria: 2015

Knowledge/awareness about HPAI H5N1

The majority of the poultry traders (94.3%, n = 380) reported to have heard about HPAI H5N1. Awareness about the disease was derived from a variety of sources. Most of the respondents (54.7%) got the information through radio and television, while personal communications with relations informed 19.1% of them about the disease. Animal health officers also played important role in information dissemination about HPAI H5N1 and 31.1% of the traders mentioned that they got the information from these field officers. More than two-thirds of the vendors (90.8%) and collectors (78.9%) reported that H5N1 outbreak had occurred in Nigeria. Additionally, most vendors (74.3%) and collectors (88.0%) mentioned that AI can be transmitted from birds to humans (zoonotic). The majority (> 70%) of the vendors and collectors mentioned that occurrence of HPAI H5N1 in traded birds often resulted in high morbidity and mortality of flocks at the market stalls. However, 70.5% of the vendors and 57.7% of collectors reported that AI can be controlled/prevented (Table 1).

Knowledge about transmission of HPAI H5N1 virus infection at LBMs

The socio-economic characteristics revealed that 83.5% of the vendors and 68.3% of collectors reported that contacts of healthy birds with blood of infected ones at markets can predispose to HPAI H5N1 viral infection. More than two-thirds of vendors and collectors (95.0% and 81.7%, respectively) mentioned that contact of healthy birds with infected faeces can be route for HPAI virus transmission among birds at LBMs. Also, 83.5% of vendors and 73.9% of collectors mentioned contacts of healthy birds with nasal discharges of infected ones to be a common route for transmission of HPAI H5N1 at LBMs. Additionally, over half of the vendors (73.2%) and collectors (60.6%) indicated that contacts of healthy birds with surfaces of fomites contaminated with infected birds can serve as route for H5N1 infection (Table 1). High proportions of the traders possessed significant ($p < 0.05$) knowledge about the routes of transmission of HPAI H5N1 virus at LBMs.

Knowledge about risk factors for HPAI H5N1 within and outside LBMs

About half of the vendors (53.3% and 54.8%) and less than half of the collectors (43.0% and 41.6%), respectively mentioned that wild birds and captive games kept together for sales and contacts of healthy birds with sick ones at markets can predispose to risk of HPAI H5N1 among birds. Also, less than one-thirds of vendors (18.0%) and collectors (30.3%) reported that disposal of dead birds in open space within and close to the markets can attract rodents that are reservoirs of HPAI virus to the markets. Furthermore, less than half of the vendors (42.5%) and collectors (26.8%) mentioned that sick birds brought into LBMs can predispose to risk of HPAI virus in LBMs. About one-third (35.2%) of the vendors and less than one-third (20.4%) of collectors mentioned that mixed bird species in cages can predisposed to risk of HPAI infection at LBMs. However, 46.4% of vendors and 30.3% of collectors mentioned that ducks kept at markets for sales can predispose to risk of HPAI virus infection. Meanwhile, about half (49.2%) of the vendors and more than one-third (38.7%) of collectors reported that unsanitary transportation of birds to and within the markets can predispose to risk of H5N1 infection (Table 2). In overall, less than half of the participating traders had significant ($p < 0.05$) knowledge about risk factors that predispose to HPAI virus infection at LBMs.

Table 1. Knowledge/awareness about HPAI H5N1 among poultry traders at LBMs of North-central Nigeria

Variable	Traders	Yes n (%)	No n (%)	χ^2	p-value
Heard about avian influenza (H5N1)	Vendors	255 (97.7)	6 (2.3)	15.99	<0.001*
	Collectors	125 (88.0)	17 (12.0)		
Avian influenza outbreaks have recently occurred in Nigeria	Vendors	237 (90.8)	24 (9.2)	11.28	<0.001*
	Collectors	112 (78.9)	30 (21.1)		
Have seen birds with clinical signs indicative of avian influenza	Vendors	78 (29.9)	183 (70.1)	2.04	0.154
	Collectors	33 (23.2)	109 (76.8)		
Avian influenza can be transmitted from birds to humans (zoonosis)	Vendors	194 (74.3)	67 (25.7)	10.46	0.001*
	Collectors	125 (88.0)	17 (12.0)		
Avian influenza is associated with high morbidity at LBMs	Vendors	207 (79.3)	54 (20.7)	6.75	0.009*
	Collectors	96 (67.6)	46 (32.4)		
Avian influenza is associated with high mortality at LBMs	Vendors	188 (72.0)	73 28.0)	7.95	0.005*
	Collectors	120 (84.5)	22 (15.5)		
Avian influenza can be controlled or prevented	Vendors	184 (70.5)	77 (29.5)	6.66	0.009*
	Collectors	82 (57.7)	60 (42.3)		
Common routes for transmission of avian influenza to birds:					
Contacts of healthy birds with blood of infected ones at LBM slaughter point	Vendors	218 (83.5)	43 (16.5)	12.47	<0.001*
	Collectors	97 (68.3)	45 (31.7)		
Contacts of healthy birds with faeces of infected ones	Vendors	248 (95.0)	13 (5.0)	16.86	<0.001*
	Collectors	116 (81.7)	26 (18.3)		
Contacts of healthy birds with nasal discharges of infected ones	Vendors	218 (83.5)	43 (16.5)	5.31	0.021*
	Collectors	105 (73.9)	37 (26.1)		
Contacts of healthy birds with saliva of infected ones	Vendors	71 (27.2)	190 (72.8)	1.93	0.166
	Collectors	48 (33.8)	94 (66.2)		
Contacts of healthy birds with surfaces of contaminated materials with infected birds	Vendors	191 (73.2)	70 (26.8)	6.81	0.009*
	Collectors	86 (60.6)	56 (39.4)		

*Statistically significant at $p < 0.05$, χ^2 – Chi square, LBM – Live bird market

Table 2. Poultry traders' knowledge about risk factors that predispose to HPAI H5N1 at LBMs in North-central Nigeria

Factor	Poultry traders	Yes n (%)	No n (%)	χ^2	p-value
Keeping wild birds and captive games in the market for sales	Vendors	139 (53.3)	122 (46.7)	3.90	0.048*
	Collectors	61 (43.0)	81 (57.0)		
Contacts of healthy birds with sick ones in the market	Vendors	143 (54.8)	118 (45.2)	6.45	0.011*
	Collectors	59 (41.6)	83 (58.4)		
Disposal of dead birds in open space within and close to the markets	Vendors	47 (18.0)	214 (82.0)	7.99	0.005*
	Collectors	43 (30.3)	99 (69.7)		
Bringing in sick birds from outside the market into cages for sales	Vendors	111 (42.5)	150 (57.5)	9.81	0.002*
	Collectors	38 (26.8)	104 (73.2)		
Mix keeping of different bird species in cages for sales	Vendors	92 (35.2)	169 (64.8)	9.62	0.002*
	Collectors	29 (20.4)	113 (79.6)		
Keeping of ducks in the market for sales	Vendors	121 (46.4)	140 (53.6)	9.85	0.002*
	Collectors	43 (30.3)	99 (69.7)		
Unsanitary transportation of birds to and within the markets	Vendors	129 (49.2)	132 (50.6)	4.24	0.039*
	Collectors	55 (38.7)	87 (61.3)		

*Statistically significant at $p < 0.05$, χ^2 – Chi square, LBM – Live bird market

Zoonotic risk perceptions for HPAI H5N1 at LBMs

Nearly two-thirds of the vendors (71.6%) and collectors (73.9%) perceived asymptomatic birds handled at LBMs to be of low zoonotic risk, while 4.6% and 11.3% of them, respectively considered same activity to be of high zoonotic risk. However, only few (14.2%) of the vendors and more than one-third (41.5%) of collectors perceived clinically sick birds handled at markets to be of high zoonotic risk. Also, few of the vendors (19.2%) and collectors (8.5%), respectively perceived faecal droppings of sick birds handled at LBMs to be of high zoonotic risk for HPAI H5N1. Less than one-thirds of vendors (19.2%) and collectors (22.5%) perceived handling of fomites used for sick birds to be of high zoonotic risks for HPAI H5N1. Furthermore, very few of the vendors (5.4%) and collectors (12.0%) perceived handling of wild birds brought to the markets to be an activity associated with high zoonotic risk (Table 3). Some handling activities were significantly ($p < 0.05$) perceived to be associated with zoonotic risks of HPAI H5N1 at LBMs (Table 3).

Table 3. Poultry traders' perceptions about zoonotic risk of HPAI H5N1 during handling activities at LBMs in North-central Nigeria

Activity	Poultry traders	Low risk n (%)	Moderate risk n (%)	High risk n (%)	χ^2	p-value
Handling asymptomatic birds	Vendors	187 (71.6)	62 (23.8)	12 (4.6)	9.55	0.008*
	Collectors	105 (73.9)	21 (14.8)	16 (11.3)		
Handling clinically sick birds	Vendors	143 (54.8)	81 (31.0)	37 (14.2)	75.27	<0.001*
	Collectors	18 (12.7)	65 (45.8)	59 (41.5)		
Handling eggs from sick birds	Vendors	52 (27.2)	181 (61.7)	28 (10.7)	114.4	<0.001*
	Collectors	103 (72.5)	25 (17.6)	14 (9.9)		
Handling faecal droppings of sick birds	Vendors	148 (56.7)	63 (24.1)	50 (19.2)	8.92	0.012*
	Collectors	97 (68.3)	33 (23.2)	12 (8.5)		
Handling fomites used for sick birds e.g. cages	Vendors	147 (56.3)	64 (24.5)	50 (19.2)	6.97	0.031*
	Collectors	61 (43.0)	49 (34.5)	32 (22.5)		
Handling wild birds brought to the markets	Vendors	199 (76.2)	48 (18.4)	14 (5.4)	7.05	0.029*
	Collectors	94 (66.2)	31 (21.8)	17 (12.0)		

Note: Low risk (< 35%); Moderate risk (35-65%); High risk (> 66%), *Statistically significant at $p < 0.05$, χ^2 – Chi-square

Table 4. Biosecurity measures practiced by poultry traders against HPAI H5N1 at LBMs in North-central Nigeria

Practice	Traders	Yes n (%)	No n (%)	χ^2	p-value
Isolation of sick birds from flock	Vendors	128 (49.0)	133 (51.0)	3.94	0.047*
	Collectors	55 (38.7)	87 (61.3)		
Regular cleaning of cages	Vendors	50 (19.2)	211 (80.8)	23.37	<0.001*
	Collectors	59 (41.5)	83 (58.5)		
Disinfecting cages	Vendors	81 (31.0)	190 (69.0)	0.66	0.415
	Collectors	48 (33.8)	94 (66.2)		
Regular cleaning of stall area	Vendors	98 (37.5)	163 (62.5)	17.25	<0.001*
	Collectors	25 (17.6)	117 (82.4)		
Regular cleaning of vehicles	Vendors	78 (29.9)	183 (70.1)	4.34	0.037*
	Collectors	57 (40.1)	85 (59.9)		
Disinfecting vehicles	Vendors	77 (29.5)	184 (70.5)	0.21	0.648
	Collectors	45 (31.7)	97 (68.3)		
Keeping birds according to species	Vendors	144 (55.2)	117 (44.8)	8.13	0.004*
	Collectors	99 (69.7)	43 (30.3)		
Keep birds according to sources	Vendors	93 (35.6)	168 (67.6)	0.43	0.514
	Collectors	46 (32.4)	96 (46.5)		
Use of personal protective equipment (PPE)	Vendors	48 (18.4)	213 (81.6)	6.11	0.013*
	Collectors	13 (9.2)	129 (90.8)		
Burial of dead birds outside markets	Vendors	79 (30.3)	182 (69.7)	10.49	0.001*
	Collectors	66 (46.5)	76 (53.5)		
Burning of dead birds in ditches outside markets	Vendors	93 (35.6)	168 (64.4)	3.86	0.049*
	Collectors	37 (26.1)	105 (73.9)		

*Statistically significant at $p < 0.05$, χ^2 – Chi-square, LBM – Live bird market

Table 5. Poultry traders' demographic and socio-economic characteristics influencing knowledge/awareness about HPAI H5N1 at LBMs in North-central Nigeria

Characteristic	Poor knowledge n (%)	Satisfactory knowledge n (%)	Odds ratio	95% CI	p-value
Age					
20-29	42 (59.2)	29 (40.8)	1.00		
30-39	36 (35.6)	65 (64.4)	2.62	1.40, 4.88	0.002*
40-49	43 (36.4)	75 (63.6)	2.53	1.38, 4.62	0.004*
50-59	28 (40.0)	42 (60.0)	2.17	1.11, 4.26	0.035*
60-69	12 (27.9)	31 (72.1)	3.74	1.65, 8.47	0.002*
Gender					
Female	48 (60.8)	31 (39.2)	1.00		
Male	153 (47.2)	171 (52.8)	1.73	1.05, 2.86	0.042*
Socio-economic					
Collectors	47 (33.1)	95 (66.9)	1.00		
Vendors	120 (46.0)	141 (54.0)	0.58	0.38, 0.89	0.016*
Education					
None	56 (50.5)	41 (49.5)	1.00		
Primary	55 (39.6)	84 (60.4)	2.09	1.23, 3.53	0.009*
Secondary	42 (40.8)	61 (59.2)	1.98	1.13, 3.48	0.024*
Tertiary	11 (17.2)	53 (82.2)	6.58	3.07, 14.13	<0.001*

*Statistically significant at $p < 0.05$, CI – Confidence interval, LBM – Live bird market

Table 6. Poultry traders' demographic and socio-economic characteristics influencing practice of biosecurity measures against HPAI H5N1 at LBMs in North-central Nigeria

Characteristic	Poor measures n (%)	Satisfactory measures n (%)	Odds ratio	95% CI	p-value
Age					
20-29	53 (74.6)	18 (25.4)	1.00		
30-39	71 (70.3)	30 (29.7)	1.24	0.63, 2.47	0.653
40-49	65 (55.1)	53 (44.9)	2.40	1.26, 4.58	0.010*
50-59	39 (55.7)	31 (44.3)	2.34	1.15, 4.77	0.029*
60-69	18 (41.9)	25 (58.1)	4.09	1.82, 9.18	0.001*
Gender					
Female	57 (72.2)	22 (27.8)	1.00		
Male	198 (61.1)	126 (38.9)	1.65	0.96, 2.83	0.087
Socio-economic					
Collectors	60 (42.3)	82 (57.7)	1.00		
Vendors	145 (55.6)	116 (44.4)	0.59	0.39, 0.88	0.014*
Education					
None	73 (75.3)	24 (24.7)	1.00		
Primary	91 (65.5)	48 (34.5)	1.60	0.89, 2.86	0.142
Secondary	56 (54.4)	47 (45.6)	2.55	1.39, 4.66	0.003*
Tertiary	22 (34.4)	42 (65.6)	5.81	2.91, 11.60	<0.001*

*Statistically significant at $p < 0.05$, CI – Confidence interval, LBM – Live bird market

Biosecurity measures practiced against HPAI H5N1 at LBMs

Stratified by trade socio-economic characteristics, less than half of the vendors (49.0%) and collectors (38.7%) significantly ($p = 0.047$) practiced isolation of sick birds from the flocks as biosecurity measures against HPAI H5N1 at LBMs. Only few of the vendors (19.2%) and less than half of the collectors (41.5%) significantly ($p < 0.001$) clean their cages regularly as measure against H5N1 virus infection among birds at LBMs. Also, less than half of the vendors (37.5%) and few collectors (17.6%) practiced ($p < 0.001$) regular cleaning of stall areas at markets. Furthermore, only 29.9% of vendors and 40.1% of collectors significantly ($p = 0.037$) practiced regular cleaning of vehicles used for transportation of birds into and within the LBMs. The majority of the vendors (55.2%) and collectors (69.7%) significantly ($p = 0.004$) practiced keeping of birds according to species either during transportation or at markets. However, only few vendors (18.4%) and collectors (9.2%) used personal protective equipment (PPE) – hand gloves, face masks and overall cloths – as preventive measure against H5N1 infection at LBMs. Furthermore, more than half of the vendors (30.3%) and collectors (46.5%) significantly (p = 0.001) practiced burial of dead birds outside LBMs as biosecurity measure. More than one-third of the vendors (35.6%) and less than one-third of the collectors (26.1%) significantly (p = 0.049) practiced burning of dead birds in ditches outside markets as biosecurity measure against HPAI H5N1 (Table 4).

Demographic and socio-economic characteristics of poultry traders that influenced their overall knowledge about HPAI H5N1 at LBMs

All the demographic and socio-economic characteristics, except marital status, were significantly (p < 0.05) associated with their satisfactory knowledge about H5N1 at univariate analysis. During multivariable logistic regressions, poultry traders in age groups 30-39 years and above were more likely to possess satisfactory knowledge about HPAI H5N1 at LBMs than those within 20-29 years. Also, male poultry traders were more likely (OR: 1.73; 95% CI: 1.05, 2.86) to possess satisfactory knowledge about HPAI H5N1 at markets than females. Vendors were less likely (OR: 0.58; 95% CI: 0.38, 0.89) to possess satisfactory knowledge about HPAI H5N1 than the collectors. Poultry traders with primary and secondary education were more likely [(OR: 2.09; 95% CI: 1.23, 3.53) and (OR: 1.98; 95% CI: 1.13, 3.48), respectively] to possess satisfactory knowledge on HPAI H5N1 at LBMs than those with no formal education. Also, traders with tertiary education were seven times more likely (OR: 6.58; 95% CI: 3.07, 14.13) to possess satisfactory knowledge about HPAI H5N1 at markets than traders with no formal education (Table 5).

Demographic and socio-economic characteristics of traders that influenced their overall practice of biosecurity measures against HPAI H5N1 at LBMs

Except the marital status, all other demographic and socio-economic characteristics of the traders significantly (p < 0.05) influenced their practice of biosecurity measures against HPAI H5N1 at univariate analysis. During multivariable logistic regression, poultry traders in age group 40-49 years were more likely (OR: 2.40, 95% CI: 1.26, 4.58) to practice satisfactory biosecurity measures against HPAI H5N1 at markets than traders within 20-29 years age group. Similarly, traders in age groups 50-59 and 60-69 years were more likely [(OR: 2.34; 95% CI: 1.15, 4.77) and (OR: 4.09; 95% CI: 1.82, 9.18), respectively] to practice satisfactory biosecurity measures against the disease at LBMs than traders of 20-29 years age group. Noteworthy, bird vendors were less likely (OR: 0.58; 94% CI: 0.39, 0.88) to practice satisfactory biosecurity measures against HPAI H5N1 than the collectors at LBMs. Furthermore, poultry traders with secondary and tertiary education were more likely [(OR: 2.55; 95% CI: 1.39, 4.66) and (OR: 5.81; 95% CI: 2.91, 11.60), respectively] to practice satisfactory biosecurity measures against HPAI H5N1 than those without formal education at the markets (Table 6).

Discussion

We found that the overall epidemiological knowledge about HPAI H5N1 among the poultry traders to be significantly high. However, only very few traders perceived high zoonotic risks for, and practice adequate biosecurity measures against the disease at LBMs. These are of great public health concern and could have contributed to the recent re-emergence and spread of the disease in Nigeria.

About 94% of the participants were found to have heard about HPAI H5N1 through radio/television, relations, and animal health officials. Information obtained from relations has been reported to be major source of information about avian influenza in Chinese communities (Voeten *et al*., 2009). Although zoonotic HPAI H5N1 has occurred in some countries, with variable case fatalities (Fasina *et al*., 2010; Wu *et al*., 2017), our study found some traders to be unaware of HPAI H5N1 to be zoonotic. This could be because infection in humans at LBMs has not been reported in Nigeria (Fasina *et al*., 2009), till date. Traders reported HPAI H5N1 to be associated with high morbidity and mortality in birds at LBMs. This is corroborated by some studies that reported HPAI H5N1 to cause high mortality in chicken flocks, with cumulative morbidity and mortality rates that may approach 90–100% (Monne *et al*., 2015; CDC, 2016). Surveyed traders were aware that contacts of susceptible birds with blood, faeces, nasal secretion and saliva of infected birds as well as contaminated surfaces are common routes for HPAI virus transmissions. Previous studies have reported that susceptible birds can pick up AI virus through direct contacts with blood, faeces, nasal secretion and saliva of infected birds or when in contacts with fomites surfaces contaminated with these materials (CDC, 2015).

Significant risk factors associated with HPAI H5N1 at the LBMs were identified and include keeping of wild birds together with captive games at markets, disposal of dead birds in open spaces within and close to the markets, mixed keeping of different bird species in a cage, and unsanitary transportation of birds to and within the markets. Studies have reported wild birds to be reservoirs of HPAI H5N1 virus worldwide (Desvaux *et al*., 2011), while mixed keeping of poultry species was reported to create cross transmission of the virus among birds (Cardona *et al*., 2009; Alhaji and Odetokun, 2011; Loth *et al*., 2011; Metras *et al*., 2012; Akanbi *et al*., 2016). Other risk factors observed were keeping of ducks in the markets for sales and introduction of sick birds into LBMs. Our finding is comparably with results of a study that reported ducks to be potential reservoirs of HPAI H5N1 virus (Coker *et al*., 2014). In Africa, poor compliance to biosecurity at LBMs are usually observed (Alhaji and Odetokun, 2013; Fasanmi *et al*., 2017).

Our study found very low proportions of traders that perceived high zoonotic risk for HPAI H5N1 during handling of sick birds. This could be because people tend to fear threats of avian influenza only when in close contacts with suspected infected birds and their tissues, or contacts with suspected infected fomites (Vong *et al*., 2009). We also observed very few traders with high zoonotic risk perceptions for the disease at handling of wild birds, faecal droppings of sick birds and contaminated fomites. This cannot be unconnected with traders' low level of awareness about zoonotic nature of the disease despite constant exposures to different poultry diseases at LBMs. Hazard exposures have been reported to cause familiarity, which may reduce perceptions of high risk with consequent dismissal of warnings as exaggerated or unrealistic (Chaudhary *et al*., 2004; Fielding *et al*., 2005).

Significant practice of keeping birds according to their species was observed among the majority of traders in this study, but only few of them kept birds according to their sources. Keeping different species of birds together, such as chickens and ducks, increases the likelihood of exposing susceptible chickens to ducks that harbour H5N1 virus (Santhia *et al*., 2009). Also, only few traders practice regular cleaning of cages, stall areas and vehicles at the LBMs. Regular cleaning and disinfecting of markets have been reported to effectively eliminate influenza viruses from surfaces and reduce risk of introduction and the spread of these agents at LBMs (Kung *et al*., 2003; Yee *et al*., 2008). The use of PPE by less than one-third of the traders during poultry handling indicates the poor patronage of this important preventive measure thereby exposing them to zoonotic threat of diseases.

This study found traders' demographic and socio-economic characteristics of age, gender, socio-economic activity and formal education to significantly have influence on their levels of knowledge about, and practices of biosecurity measures against HPAI H5N1 at LBMs. Given the observed variable epidemiological knowledge about, and inadequate preventive practices against HPAI H5N1 among age groups, gender and education in this study, training courses for peer groups is recommended such that educated traders can share their knowledge with others. Formal education is a very important factor that can promote traders' knowledge about HPAI and practices of biosecurity measures, as previously reported (Kuo *et al*., 2011, Elelu, 2017). Furthermore, delivery of messages via intermediaries such as traders' union leaders is suggested as it can be more effective than mass media or government communication programs. These observations are all consistent with the reports of some studies (Manabe *et al*., 2011).

This study shows that traders neither possessed adequate knowledge about zoonotic nature of HPAI H5N1 nor practice adequate biosecurity measures against the disease at LBMs in Nigeria. Their belief that HPAI is lethal only in birds further predisposes them to risk of likely human infection with the virus. Previous studies have reported low level of preventive practices against AI at LBMs and attributed it to low perceived threat by the workers (Manabe *et al*., 2011; Elelu, 2017). Hence public health campaign strategies that will involve education on zoonotic related risks to people involved in poultry business is advocated. Because of poor biosecurity practices observed, communication channels of print media and focus health education talks on preventive practices from health and veterinary authorities at market places are suggested.

A possible limitation to this study was that data used were obtained from a cross-sectional study that does not show causal relationship. It does demonstrate association of demographic characteristics with levels of knowledge and biosecurity practices. The use of measures of central tendency, especially during regression analysis, would be valuable enough to tolerate the likely imperfections in the confidence intervals and the selection of participants that was based on systematic sampling that may have brought in biases. However, we believe this bias was controlled since the surveyed LBMs were homogenous in nature.

Conclusion

The majority of the traders averagely expressed significant epidemiological knowledge about HPAI H5N1, which were found to be influenced by their socio-demographic characteristics. However, high zoonotic risk perceptions and practices of biosecurity measures in the markets were not optimal, posing public health challenges. A multidisciplinary collaborative team of veterinary, public health and communication authorities are recommended for the development of education programmes and regulatory measures that will enhance poultry traders' zoonotic awareness level and better biosecurity management of zoonotic and pandemic risks prevention and control at the live bird markets.

Acknowledgments

The authors express their profound gratitude to the leaders of the surveyed live bird markets for their assistance in coordinating the research at their domains. We also wish to thank the contracted enumerators for complying with the instructions given them on questionnaires administrations.

Conflict of interest

The authors declare that they have no conflict of interest.

References

Akanbi, O.B., Ekong, P.S., Odita, C.I. and Taiwo, V.O. (2016). The effect of highly pathogenic avian influenza (HPAI) H5N1 outbreaks on mixed species poultry farms in Nigeria. *Journal of World Poultry Research*, 6(3): 147–152.

Alhaji, N. B. and Odetokun, I. A. (2013). Biosecurity measures against highly pathogenic avian influenza (HPAI) in free-range flocks and commercial poultry in developing countries: A review. In: *Avian Influenza: Molecular Evolution, Outbreaks and Prevention/Control.* Taylor, K.M. and Connor, B.O. (eds). NOVA Publishers, USA. pp 23-48.

Alhaji, N.B. and Odetokun, I.A. (2011). Assessment of biosecurity measures against highly pathogenic avian influenza risks in small-scale commercial farms and free-range poultry flocks in the Northcentral Nigeria. *Transboundary and Emerging Diseases*, 58: 157–161.

Brown, M., Moore, L., McMahon, B., Powell, D., LaBute, M., Hyman, J.M., Rivas, A., Jankowski, M., Berendzen, J., Loeppky, J., Manore, C. and Fair, J. (2015). Constructing rigorous and broad biosurveillance networks for detecting emerging zoonotic outbreaks. *PLoS One*, 10(5): e0124037.

Cardona, C., Yee, K. and Carpenter, T. (2009). Are live bird markets reservoirs for avian influenza? *Poultry Science*, 88(4): 856–859.

Centers for Disease Control and Prevention (CDC). (2015). Transmission of avian influenza H5N1 in birds. Available at https://www.cdc.gov/flu/avianflu/avian-in-birds.htm. Accessed on 03 Aug 2016.

Centers for Disease Control and Prevention (CDC). (2016). Avian flu. Available at https://www.cdc.gov/flu/avianflu/. Accessed on 03 Aug 2016.

Chaudhary, N.K., Solomon, M.G. and Cosgrove, L.A. (2004). The relationship between perceived risk of being ticketed and self-reported seat belt use. *Journal of Safety Research*, 35: 383–390.

Chen, S., Li, Z., Hu, M., Guo, S., Wu, J., Wang, B., Hu, W., Sun, Y., Li, H., Liu, M., Moore, J.B. and Chen, H. (2015). Knowledge, attitudes, and practices (KAP) relating to avian influenza (H10N8) among farmers' markets workers in Nanchang, China. *PLoS One*, 10: 1–12.

Coker, T., Meseko, C., Odaibo, G. and Olaleye, D. (2014). Circulation of the low pathogenic avian influenza subtype H5N2 virus in ducks at a live bird market in Ibadan, Nigeria. *Infectious Diseases of Poverty*, 2014; 3: 38.

De Zwart, O., Veldhuijzen, I.K., Elam, G., Aro, A.R., Abraham, T., Bishop, G.D., Richardus, J.H. and Brug, J. (2007). Avian influenza risk perception, Europe and Asia. *Emerging Infectious Diseases*, 13(2): 290–293.

Dean, A.G., Sullivan, K.M. and Soe, M.M. (2009). Open Source Epidemiologic Statistics for Public Health (OpenEpi), Version 2.3.1. Available at http://www.openepi.com/Menu/OE_Menu.htm. Accessed on 09 Aug 2016.

Desvaux, S., Grosbois, V., Pham, T.T.H., Fenwick, S., Tollis, S. and Pham, N.H. (2011). Risk factors of highly pathogenic avian influenza H5N1 occurrence at the village and farm levels in the Red River Delta region in Vietnam. *Transboundary and Emerging Diseases*, 58(6): 492–502.

Elelu, N. (2017). Epidemiological risk factors of knowledge and preventive practice regarding avian influenza among poultry farmers and live bird traders in Ikorodu, Lagos State. *International Journal of Veterinary Science and Medicine*, 5(1): 47-52.

Fasanmi, O.G., Odetokun, I.A., Balogun, F.A. and Fasina, F.O. (2017). Public health concerns of highly pathogenic avian influenza H5N1 endemicity in Africa. *Veterinary World*, 10(10): 1194-1204.

Fasina, F.O., Ifende, V.I. and Ajibade, A.A. (2010). Avian influenza A (H5N1) in humans: lessons from Egypt. *Euro Surveillance*, 15(4): pii=19473.

Fasina, O.F., Disschop, S.P.R., Ibironke, A.A. and Meseko, C.A. (2009). Avian influenza risk perception among poultry workers, Nigeria. *Emerging Infectious Diseases*, 15(4): 616–617.

Fielding, R., Lam, W.W.T., Ho, E.Y.Y., Lam, T.H., Hedley, A.J. and Leung, G.M. (2005). Avian influenza risk perception, Hong Kong. *Emerging Infectious Diseases*, 11(5): 6777–882.

Food and Agriculture Organization of the United Nations (FAO). (2013) Mapping Influenza A (H5N1) virus transmission pathways and critical control points in Egypt. Animal Production and Health Working Paper No. 11. Rome.

Food and Agriculture Organization of the United Nations (FAO). (2015). H5N1 HPAI spread in Nigeria and increased risk for neighbouring countries in West Africa. *Empress Watch*, 32, Rome.

Fournié, G., de Glanville, W.A. and Pfeiffer, D.U. (2011). Epidemiology of highly pathogenic avian influenza virus strain type H5N1. In: *Health and Animal Agriculture in Developing Countries*. Zilberman, D., Otte, J., Roland-Holst, D. and Pfeiffer, D, (eds). Springer, New York, USA.

Guan, Y. and Smith, G.J. (2013). The emergence and diversification of panzootic H5N1 influenza viruses. *Virus Research*, 178: 35–43.

Horm, S.V., Tarantola, A., Rith, S., Ly, S., Gambaretti, J., Duong, V., Phalla, Y., Sorn, S., Holl, D., Allal, L., Kalpravidh, W., Dussart, P., Horwood, P.F. and Buchy, P. (2016). Intense circulation of A/H5N1 and other avian influenza viruses in Cambodian live-bird markets with serological evidence of sub-clinical human infections. *Emerging Microbes and Infection*, 5: e70.

Indriani, R., Samaan, G., Gultom, A., Loth, L., Irianti, S., Adjid, R., Dharmayanti, N.L.P.I., Weaver, J., Mumford, E., Lokuge, K., Kelly, P.M. and Darminto. (2010). Environmental sampling for avian influenza virus A (H5N1) in live-bird markets, Indonesia. *Emerging Infectious Diseases*, 16(12): 1889–1895.

Joannis, T., Lombin, L.H., De Benedictis, P., Cattoli, G. and Capua, I. (2006). Confirmation of H5N1 avian influenza in Africa. *Veterinary Record*, 158: 309–310.

Kung, N.Y., Guan, Y., Perkins, N.R., Bissett, L., Ellis, T., Sims, L., Morris, R.S., Shortridge, K.F. and Peiris, J.S. (2003). The impact of a monthly rest day on avian influenza virus isolation rates in retail live poultry markets in Hong Kong. *Avian Diseases*, 47(Suppl.3): 1037–1041.

Kuo, P.C., Huang, J.H. and Liu, M.D. (2011). Avian influenza risk perception and preventive behavior among traditional market workers and shoppers in Taiwan: Practical implications for prevention. *PLoS One*, 6(9): e24157.

Leppin, A. and Aro, A.R. (2009). Risk perceptions related to SARS and avian influenza: theoretical foundations of current empirical research. *International Journal of Behavioral Medicine*, 16: 7–29.

Li, C., Hatta, M., Nidom, C.A., Muramoto, Y., Watanabe, S., Neumann, G. and Kawaoka, Y. (2010). Reassortment between avian H5N1 and human H3N2 influenza viruses creates hybrid viruses with substantial virulence. *Proceedings of the National Academy of Science, USA*, 107(10): 4687–4692.

Loth, L., Gilbert, M., Wu, J., Czarnecki, C., Hidayat, M. and Xiao, X. (2011). Identifying risk factors of highly pathogenic avian influenza (H5N1 subtype) in Indonesia. *Preventive Veterinary Medicine*, 102(1): 50–58.

Manabe, T., Pham, T.P., Vu, V.C., Takasaki, J., Huyen, D.T. T., Chau, N.T.M., Shimbo, T., Ha, B.T.T., Izumi, S., Hanh, T.T., Chau, N.Q. and Kudo, K. (2011). Impact of educational intervention concerning awareness and behaviors relating to avian influenza (H5N1) in a high-risk population in Vietnam. *PLoS One*, 6(8): e23711.

Metras, R., Stevens, K.B., Abdu, P., Okike, I., Randolph, T., Grace, D., *et al*. (2012). Identification of potential risk factors associated with highly pathogenic avian influenza subtype H5N1 Outbreak Occurrence in Lagos and Kano states, Nigeria, during the 2006–2007 epidemics. *Transboundary and Emerging Diseases*, 60(1): 87–96.

Monne, I., Meseko, C., Joannis, T., Shittu, I., Ahmed, M., Tassoni, L., Fusaro, A. and Cattoli G. (2015). Highly Pathogenic Avian Influenza A (H5N1) Virus in Poultry, Nigeria, 2015. *Emerging Infectious Diseases*, 21(7): 1275–1277.

Naysmith, S. (2014). Observations from a Live Bird Market in Indonesia Following a Contained Outbreak of Avian Influenza A (H5N1). *EcoHealth*, 1: 50–52.

Santhia, K., Ramy, A., Jayaningsih, P., Samaan, G., Putra, A.A.G., Dibia, N., Sulaimin, C., Joni, G., Leung, C.Y.H., Peiris, J.S.M., Wandra, T. and Kandun, N. (2009). Avian influenza A H5N1 infections in Bali province, Indonesia: A behavioral, virological and sero-epidemiological study. *Influenza Other Respiratory Viruses*, 3: 81–89.

Sims, L. (2012). Progress in Control of H5N1 Highly Pathogenic Avian Influenza and the Future Eradication. *Avian Diseases*, 56: 829–835.

Suarez, D.L., Senne, D.A., Banks, J., Brown, I.H., Essen, S.C., Lee, C.W., Manvell, R.J., Mathieu-Benson, C., Moreno, V., Pedersen, J.C., Panigrahy, B., Rojas, H., Spackman, E. and Alexander, D.J. (2004). Recombination resulting in virulence shift in avian influenza outbreak, Chile. *Emerging Infectious Diseases*, 10: 693–699.

Voeten, H.A., de Zwart, O., Veldhuijzen, I.K. and Yuen C. (2009). Sources of information and health beliefs related to SARS and avian influenza among Chinese communities in the United Kingdom and The Netherlands, compared to the general population in these countries. *International Journal of Behavioral Medicine*, 16: 49–57.

Vong, S., Ly, S., Van Kerkhove, M.D., Achenbach, J., Holl, D., Buchy, P., Sorn, S., Seng, H., Uyeki, T.M., Sok, T. and Katz, J.M. (2009). Risk factors associated with subclinical human infection with avian influenza A (H5N1) virus – Cambodia, 2006. *Journal of Infectious Diseases*, 199(12): 1744–1752.

Wan, X., Dong, L., Lan, Y., Long, L-P., Xu, C., Zou, S., Li, Z., Wen, L., Cai, Z., Wang, W., Li, X., Yuan, F., Sui, H., Zhang, Y., Dong, J., Sun, S., Gao, Y., Wang, A., Bai, T., Yang, L., Li, D., Yang, W., Yu, H., Wang, S., Feng, Z., Wang, Y., Guo, Y., Webby, R.J. and Shu, Y. (2011). Indications that live poultry markets are a major source of human H5N1 influenza virus infection in China. *Journal of Virology*, 85(24): 13432–13438.

Webster, R.G. (2004). Wet markets-a continuing source of severe acute respiratory syndrome and influenza? *Lancet*, 363: 234–236.

World Organisation for Animal Health (OIE). (2015). Update on highly pathogenic avian influenza in animals (Type H5 and H7), Paris. Available at http://www.oie.int/animal-health-in-the-world/update-on-avian-influenza/2015/. Accessed on 03 Aug 2016.

World Organization for Animal Health (OIE). (2016). Update on highly pathogenic avian Influenza in animals (type H5 and H7), Paris. http://www.oie.int/en/animal-health-in-the-world/update-on-avian-influenza/2016/. Accessed on 03 Aug 2016.

Wu, Z., Zhang, Y., Zhao, N., Yu, Z., Pan, H., Chan, T., Zhang, Z. and Liu, S. (2017). Comparative epidemiology of human fatal infections with novel, high (H5N6 and H5N1) and low (H7N9 and H9N2) pathogenicity avian influenza A viruses. *International Journal of Environmental Research and Public Health*, 14(3): 263.

Yee, K.S., Carpenter, T.E., Mize, S. and Cardona, C.J. (2008). The live bird market system and low-pathogenic avian influenza prevention in southern California. *Avian Diseases*, 52: 348–352.

Yupiana, Y., de Vlas, S.J., Adnan, N.M. and Richardus, J.H. (2010). Risk factors of poultry outbreaks and human cases of H5N1 avian influenza virus infection in West Java Province, Indonesia. *International Journal of Infectious Diseases*, 14(9): e800 –e805.

Zhou, X., Li, Y., Wang, Y., Edwards, J., Guo, F. and Clements, A.C.A. (2015). The role of live poultry movement and live poultry market biosecurity in the epidemiology of influenza A (H7N9): A cross sectional observational study in four eastern China Province. *Journal of Infection*, 71 (4): 470–479.