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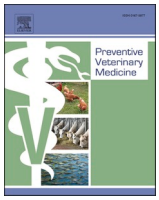

UK flockdown: A survey of smallscale poultry keepers and their understanding of governmental guidance on highly pathogenic avian influenza (HPAI)

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ABSTRACT

The scale of the current outbreak of highly pathogenic avian influenza (HPAI) due to the A/H5N1 virus in the United Kingdom is unprecedented. In addition to its economic impact on the commercial poultry sector, the disease has devastated wild bird colonies and represents a potential public health concern on account of its zoonotic potential. Although the implementation of biosecurity measures is paramount to reducing the spread of HPAI in domestic and commercial settings, little is known about the attitudes and perspectives of backyard poultry keepers, who often keep their flocks in close proximity to the public. A large nationwide survey of backyard poultry keepers was undertaken in December 2021–March 2022, contemporaneous with the enforcement of an Avian Influenza Prevention Zone (AIPZ) and additional housing measures in England, Scotland and Wales. The survey explored keepers' understanding of the clinical manifestations of HPAI, compliance with housing and biosecurity measures, attitudes towards obligatory culling on confirmation of HPAI in their flocks, and the potential use of vaccination to control HPAI. Summary statistical analysis of the closed question responses was supplemented with qualitative data analysis and corpus linguistic approaches to draw out key themes and salient patterns in responses to open text questions. Survey responses were received from 1559 smallscale poultry keepers across the United Kingdom. Awareness of the HPAI outbreak was very high (99.0%). The majority of respondents learned of it via social media (53%), with Defra (49.7%), British Hen Welfare Trust (33.8%) and the APHA (22.0%) identified as the principal sources of information. Analysis revealed that backyard keepers lacked knowledge of the clinical signs of avian influenza and legal requirements relating to compliance with biosecurity measures. Some respondents dismissed the seriousness of HPAI and were unwilling to comply with the measures in force. The issue of obligatory culling proved highly emotive, and some expressed a lack of trust in authorities. Most respondents (93.1%) indicated a willingness to pay for vaccination if the option was available. Communications on biosecurity measures that are relevant to large-scale industrial setups are inappropriate for backyard contexts. Understanding the barriers that backyard keepers face is essential if official agencies are to communicate biosecurity information effectively to such groups. Lack of trust in authorities is likely to make elimination of the virus in the UK difficult. We make recommendations for tailoring HPAI-related information for backyard contexts, to aid future HPAI control measures in the UK.

1. Introduction

The onset of the current panzootic of highly pathogenic avian influenza (HPAI) can be traced to South East Asia and the isolation of a novel influenza A/H5N1 virus from geese in Guangdong Province, China, in 1996 (Chen et al., 2006; Xu et al., 1999). Since then, the virus has spread widely along the transcontinental flyways of migratory birds (Smallman-Raynor and Cliff, 2008), and has been subject to mutation (antigenic drift), re-assortment (antigenic shift), and, more rarely, recombination (Shao et al., 2017) to yield new H5N1 variants that have

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the potential to cause severe disease and death in wild and domestic avian species and, occasionally, humans and other animals. HPAI viruses usually arise via mutation from low pathogenic avian influenza (LPAI) viruses that are endemic in waterfowl, with the 'high' and 'low' designations deriving from their pathogenicity in domestic chickens. Usually, HPAI viruses occur sporadically in chickens and are eliminated by death or culling (due to statutory restrictions), so the current situation of an HPAI virus causing widespread morbidity and mortality in both domestic and wild bird populations is unusual.

The scale of the current outbreak of H5N1 in the United Kingdom is unprecedented. Beginning with a case at a swan sanctuary in Worcester on 15 October 2021, the outbreak has extended over two avian influenza seasons (2021–22 and 2022–23) and has been associated with many hundreds of reported cases in wild and domestic birds (Food and Agriculture Organisation of the United Nations, 2023). Measures to prevent the spread of the disease were implemented early in the 2021–22 season; an Avian Influenza Prevention Zone (AIPZ) came into force in England, Wales and Scotland on 3 November 2021 and additional housing order measures were in place from 29 November 2021 to 2 May 2022 (Freath et al., 2022). The present study covers this first season of HPAI control, although similar housing measures were also implemented in England and Wales between 7 November 2022 and 18 April 2023.

Until recently, backyard poultry was not considered a major factor in the transmission of HPAI in Europe (Bavinck et al., 2009). However, between 21 October 2021 and 4 April 2022, 33 of 103 premises (25.4%) in the UK with confirmed HPAI cases were described as 'small flock', 'smallholding' or 'backyard' (Freath et al., 2022), suggesting that their importance may have been underestimated. As these birds are kept in close proximity to the public, and described by many backyard keepers as 'pets', the zoonotic potential of H5N1 is a public health concern. Indeed, the first human case of H5N1 infection in the United Kingdom was reported on 5 January 2022 in a person who had close, regular contact with 125 ducks kept in and around their home (Oliver et al., 2022; UK Government, 2022).

Research into types of poultry production systems internationally puts them into four categories, some or all of which may be present simultaneously in particular countries: 1) Integrated industrial companies with high-value production chains and high biosecurity control for infectious diseases; 2) commercial independent intensive producers using external slaughterhouses or markets and moderate to high biosecurity; 3) commercial farms with poor biosecurity practices supplying to live poultry markets or traders who on-sell live birds; and 4) small flock systems varyingly described as village, scavenging, backyard or small holder systems characterised by small flocks kept largely for personal or local consumption (Sims, 2008). Biosecurity is typically low in these small flocks (Ayala et al., 2022; Hamilton-West et al., 2012; Indrawan et al., 2018; Jewitt et al., 2023; Karabozhilova et al., 2012; Sims, 2013). Risks and consequences of avian influenza outbreaks vary considerably between these systems, with category 1 flocks at low risk of an incursion but with very high consequence of one due to the number and commercial value of the animals involved. Category 3 systems are the highest risk due to bird numbers, trading practices and poor biosecurity practices, while category 4 systems are at high risk for individual flocks but as these flocks are typically isolated from each other and comprise a small number of animals, the overall impact of outbreaks in these flocks is low.

Poultry systems in the UK generally fall into category 1 or 4 systems. The UK commercial industry is highly structured with most production occurring in a typically intensive, integrated pyramidal system dominated by a limited number of companies, with a relatively small number of elite breeding flocks used to produce 'broilers' and 'layers' (Irvine, 2015; Farm Advisory Service, 2021). There were an estimated 131 million birds in commercial production systems in June 2023 (broiler 91 M, breeding and laying 32 M, turkeys 2.4 M) (Defra, 2023). Commercial holdings are particularly concentrated in certain geographic areas (Farm Advisory Service, 2021; APHA, 2021).

A recent survey conducted by ChickenGuard suggests that in 2019, there were a total of 1,028,000 chicken owners in the UK, rising to 1,338,000 in 2020 (MRCVSonline, 2020). Rehoming of commercial laying hens at the end of their production cycles is an increasingly popular source of domestic chickens with charity organisations such as the British Hen Welfare Trust, Fresh Start for Hens and Chicken Rescue UK rehoming up to 150,000 hens annually. Additionally, there is an active network of poultry shows and fancy, traditional or rare breed clubs with over 50 breed clubs listed with The Poultry Club of Great Britain (The Poultry Club, 2024). There is, however, little structured data on this sector (Correia-Gomes and Sparks, 2020) meaning that they are generally not considered in supply chain analysis or the design of veterinary infectious disease surveillance in the UK (Irvine, 2015). This reflects the fact that the UK's Department for Environment, Food & Rural Affairs (Defra) only requires keepers with 50 or more birds (in Great Britain), to register their flocks on the GB poultry register, although keepers with fewer birds may register voluntarily (UK Government, 2023a). While a consultation is currently underway to assess views on changing the regulations so all bird keepers would have to register, irrespective of the size of their flock (Defra and APHA, 2023b), the current lack of information on small-scale poultry flocks potentially reduces the ability to control the spread of HPAI and other poultry-related infectious diseases.

In developing countries where qualitative research has been undertaken to understand backyard poultry keepers' knowledge of HPAI (Conan et al., 2012; Rimi et al., 2018; Tiensin et al., 2005; Sultana et al., 2012), it is understood that biosecurity measures are paramount to reducing the spread of HPAI. Despite small holder flocks being generally characterised by a lack of biosecurity measures (Ayala et al., 2022; Hamilton-West et al., 2012; Indrawan et al., 2018; Irvine, 2015; Jewitt et al., 2023; Karabozhilova et al., 2012; Sims, 2013), there is still a relatively poor understanding of the knowledge and responses of UK backyard poultry keepers in relation to HPAI (Correia-Gomes and Sparks, 2020). This requires further investigation if government agencies and poultry welfare groups are to promote good practice and reduce HPAI cases. It appears that backyard keepers often lack an understanding of the legal requirements in relation to varying avian influenza restrictions (Correia-Gomes and Sparks, 2020) alongside a general lack of disease knowledge and biosecurity (Ayala et al., 2022; Correia-Gomes and Sparks, 2020; Jewitt et al., 2023; Karabozhilova et al., 2012). This may be due to a misunderstanding of the guidance from official sources, which is predominantly aimed at commercial flocks. The published guidance on the UK Government website outlines biosecurity measures that should be put in place to control the spread of disease. Although government guidance (Defra and APHA, 2023b) contains a section with advice on lighting, ventilation and feather picking, none of the measures directly addresses the cost implications for small-scale poultry keepers or those with a lack of facilities. Very little information from official sources is targeted specifically towards small-scale keepers, yet understanding the barriers that they face is essential if official agencies are to communicate crucial biosecurity information in a way that is understandable and can be appropriately implemented in a backyard context.

In addition to biosecurity measures, the potential utility of vaccines for HPAI control is gaining some traction. Vaccination against avian influenza is not currently approved for use in the UK although a recent report commissioned by Defra's Chief Scientific Adviser (UK Government, 2023b) highlights its potential to reduce both the amount of circulating virus and the numbers of birds culled. Key barriers that would need to be overcome include trade-related restrictions, vaccine availability, the rapid and unpredictable mutation of influenza viruses, and the practicality of injecting individual birds more than once, as a second dose may be required four to six weeks after the first (Defra and APHA, 2021; UK Government, 2023b). In the EU, attitudes towards vaccination have changed recently in response to significant losses to the poultry industry and rising concern for human health (European

Commission, 2023). In France, for example, HPAI vaccine trials have begun to assess the efficacy of HPAI vaccines in ducks and geese (Linden, 2022) and experimental trials are also taking place in Italy and the Netherlands (UK Government, 2023b). Should vaccination become standard practice, there is a gap in knowledge surrounding UK backyard keepers' opinions on vaccination and potential vaccination uptake.

The present paper explores the small-scale poultry keepers' understanding and responses in relation to HPAI biosecurity measures and vaccination in the 2021–22 season of the current HPAI outbreak in the United Kingdom. Drawing on a nationwide survey dataset involving 1559 backyard poultry keepers, representing the largest survey of its type yet reported, our results highlight gaps in understanding and assumptions that may be detrimental to the control and potential elimination of avian influenza in the UK. We believe that our results have important implications for the future control of HPAI in the UK.

2. Material and methods

Surveys using questionnaires are established methods for examining the attitudes and perspectives of backyard poultry keepers; see, for example, Correia-Gomes and Sparks (2020) and Tenzin et al. (2017). To explore the understanding and responses of small-scale poultry keepers in relation to HPAI biosecurity measures and vaccination in the UK, an online survey was designed by RT, MC and SE using Microsoft forms.

The survey comprised 21 questions of which 16 were close-ended, and five (Q14 and Q16–19) invited open text responses. The full survey and associated skip logic can be found in Appendix 1. Partial postcodes were requested (Q1) along with details of the numbers and types of birds kept (Q2–4) and the nature of the setting (Q7) to provide information on the distribution of respondents and their flock types. To maintain anonymity, no other identifying information was sought although respondents interested in receiving the survey results had the option to provide an email address. Information on how and where birds were kept, potential for contact with wild birds and types of coop/run used was requested to indicate biosecurity levels (Q5–8). Those deemed less biosecure included: free range settings; pens with opportunities for contact with birds from outside the flock; runs with earth floors; and wooden coops that would be difficult to disinfect. To explore variations in keepers' knowledge of avian influenza and broader poultry keeping regulations, information was sought on knowledge about the poultry register (Q9–10), awareness of the recent avian influenza outbreak (Q11) and associated sources of information (Q12–13), understanding of the mandatory housing order (Q14) and ease of compliance with it (Q15). An optional open text question was provided for those who could not implement the housing measures to expand on the difficulties they experienced (Q16). Respondents' knowledge of the signs of, and reporting procedures for, suspected avian influenza and views about obligatory culling of all birds on the premises of a confirmed case were sought in three open text questions (Q17–19). The last two questions (Q20–21) sought information on whether and how much keepers would pay for a vaccine (if one were available and offered as an alternative to mandatory housing measures) and their preferences for administering such a vaccine.

Ethics permission was granted by the School of Veterinary Medicine and Science, University of Nottingham Committee for Animal Care and Research (CARE) (Ref: 3523211209). The survey was piloted in December 2021 with a mixed cohort of volunteers with expertise in veterinary medicine and practical experience of backyard poultry keeping. It was then modified for clarity and made publicly available from 4 December 2021 to 31 March 2022. The first question in the survey asked participants to tick a box to consent to their participation in the study and the use of their data for non-commercial purposes. We explicitly stated that anyone under the age of 16 would require parental or guardian consent to participate.

'Backyard' or 'small-scale' poultry keepers were the key target group (see supplementary file) for the survey and respondents were drawn from across the UK (Fig. 1). Definitions of backyard keepers often refer to the number of birds kept, with Correia-Gomes (2020) including those with up to 60 birds, whilst Kyle and Sutherland (2018) include those with under 500 birds. Other definitions consider those whose birds are included on an official poultry register or those without a functional connection to commercial poultry establishments (Smith and Dunipace, 2011). Noting this lack of definitional consensus for what constitutes a 'backyard keeper', we elected to allow keepers to self-define as 'small-scale' for participation in this study. Over 96% of respondents reported keeping 50 or fewer birds.

Respondents were recruited via a range of routes including advertising on Facebook groups; an advert in the January 2022 British Hen Welfare Trust (BHWT) email digest, and local poultry keeper networks. Facebook groups that circulated the survey included: Backyard Ducks; Chicken & Poultry Keeping UK; Chicken and Poultry Keeping Uk (sic); Chicken Keepers UK; ducks ducks & ducks UK; Ducks UK; Ex Battery Hens Forum; Fresh Start for Hens; Keeping Hens and Poultry for Beginners; Omlet Chicken Keeping Community UK; Poultry UK; Quail Breeding in the UK; Raising Ducks; Silkies for pets, UK; Small holding, animal and poultry keeping; Sustainable Chicken & Duck Keepers UK; The Hen House; and UK Poultry Rehomers. Additional information on the sampling strategy, target group and data analysis approaches used can be found in Supplementary file 1.

2.1. Analysis of closed questions

Responses to the 16 closed questions were cleaned and managed, and summary statistical analysis was undertaken in Microsoft Excel (v2303). The total sum of responses was greater than the number of respondents for some questions (Q2, Q4, Q6, Q8, Q13), as respondents could select more than one option.

2.2. Analysis of open text questions: Corpus linguistics

Following McClaughlin et al. (2023), formal analysis of open question responses was undertaken by EM and TP using analytical techniques drawn from corpus linguistics and discourse analysis. A corpus linguistic approach involves the analysis of a digitised body of texts called a 'corpus' (plural 'corpora') using specialist software to identify patterns occurring in language. By treating responses to each open text question as separate corpora, the approach provides a means of drawing out statistically salient patterns in the language used by survey respondents. In this way, a corpus-assisted approach to discourse analysis protects against 'cherry-picking' of convenient or expected patterns in language use (Gillings et al., 2023, p. 1). Primarily quantitative corpus linguistic approaches to analysis applied in this paper included examination of: (i) 'frequency' (i.e., how often words feature in our datasets); (ii) 'collocation' to explore words that frequently co-occur in a statistically salient way (i.e., 'collocates') in the data to reveal patterns of meaning; and (iii) 'key semantic domains' (sets of words in the responses that are related in meaning – see Rayson (2008) characteristic of the language used to discuss HPAI. Examples of semantic domains include 'mental actions and processes', and 'anatomy and physiology' and these were extracted by comparing the language of the survey responses with that of a 'reference corpus' of general English (see supplementary file for details). The rationale for these approaches can be found in the supplementary file. Next, to further explore patterns of meaning, we (TP, EM) undertook a more qualitative discourse analysis of longer extracts of text called 'concordance lines', which show the linguistic context for a word or pattern of interest. In particular, we examined social actors, actions and semantic domains surrounding salient words and phrases. Discourse may be defined in this context as the "the characteristic ways of using language associated with particular institutions or groups" (Stibbe, 2012, p. 54). Discourse and social practice are dialectical and so we understand the discourses of small-scale keepers and government agencies to point to particular social attitudes (and the related actions,

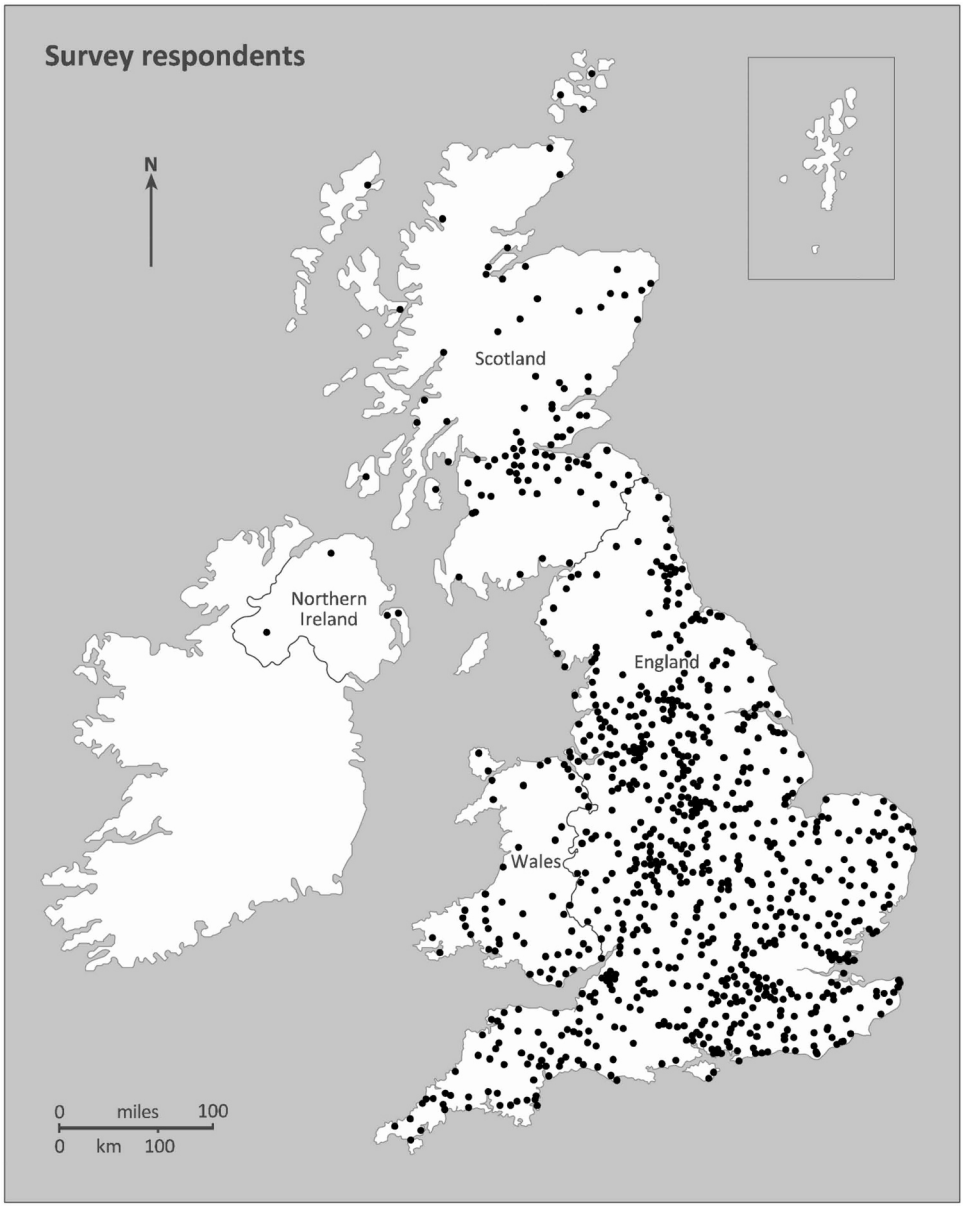

Fig. 1. Locations of respondents to keepers' survey.
Source: redrawn from Jewitt et al. (2023), (Fig. 1, p. 5).

or inactions, that are reasoned to follow), and for social attitudes to influence discourses in a mutually reinforcing way.

As a basis for the analysis, Table 1 provides descriptive statistics of the responses to the open text survey questions, including the total number of responses to each question and the total number of words ('tokens') provided in the responses. With just 171 responses, Q16 question did not yield enough data for a full corpus linguistic analysis and as such, does not appear in Table 1. Key semantic domains were analysed using the online corpus analysis tool WMatrix (Rayson, 2003) and all other corpus linguistic analyses were undertaken in Sketch Engine (Kilgarriff et al., 2014). The results of the analysis are summarised in Sections 3.3–3.5. Anonymised quotes from respondents that appear in Section 3 are denoted by respondent number (e.g., R123) with short extracts also appearing in Table 3.

Table 1
Descriptive statistics for the open text survey question corpora.

Open text survey questions	No. of responses	Tokens (total no. of words)
After receiving this information, what do you understand you need to do as part of the mandatory housing order? (Q14)	1514	22,244
If you couldn't implement the housing measures, please tell us why. If this doesn't apply, please leave blank (Q16)	171	3558
What would make you suspect your birds had Avian Influenza? (Q17)	1556	9623
What are your views on the obligatory culling of all birds on the premises of a confirmed Avian Influenza case? (Q19)	1556	17,2756
Totals	**4807**	**44,426**

Table 3
Illustrative extracts from responses to Q14, "After receiving this information, what do you understand you need to do as part of the mandatory housing order?" and Q19, "What are your views on the obligatory culling of all birds on the premises of a confirmed Avian Influenza case?" Base: 1559 adults self-defining as small-scale keepers, 4 December – 31 March 2022.

Question no	Extract Ref	Keeper response	Respondent number, amount and type of birds kept
Q.14	A	All feed and water [should be] *under cover*'	R83. 1-10 chickens
	B	**Cover** run with scaffold netting to stop wild birds entering	R116. 1-20 chickens and quail
	C	**minimise** contact between my flock and other birds	R814. 1-10 chickens
	D	do what is possible to **minimise** contact with wild birds whilst not significantly impacting on welfare	R951. 51-100 birds
	E	**minimise** contact with wild birds by covering the run	R964. 1-10 chickens
	F	Not **allow** my birds to have contact with wild birds or have access to their area	R337. 1-10 chickens
	G	Not **allowing** the chickens to free range	R1380. 11-20 chickens
	H	Netted off an area to **allow** my choocks (sic) outside access but not allow wild birds in	R364. 1-10 chickens
	I	Change of shoes so things aren't walked in from other areas	R1470. 1-10 chickens
	J	have separate foot wear (sic) that I only wear in their run	R37. 21-50 chickens
	K	'use a specific set of out door (sic) coat, hat and scarf solely only for my girls completely stored away from any other outdoor coats/hats/scarves'	R140. 1-10 chickens
	L	I found the information very confusing and had to get clarification. But eventually I understand that they had to be in a *cover* area	R124. 1-10 chickens
	M	not sure	R131. 1-10 ducks
	N	not much as I don't have 50 [birds]!	R610. 1-10 chickens
	O	I will be doing nothing.	R689. 1-10 chickens
	P	do I HAVE to do anything? Is it guidelines?	R1473. 11-20 chickens
Q.19	Q	I think they should be given the chance	R1506. 1-10 chickens
	R	I think I would want to isolate individually so I am not culling health healthy beloved pet, it's different for poultry farmers	R1474. 1-10 chickens
	S	I think the birds should be tested first and only infected/carriers should be culled	R101. 11-20 chickens
	T	Understand the requirement but would be reluctant to report unless absolutely sure	R87. 21-50 chickens
	U	I wonder how necessary it is to cull, as long as there is containment. I believe defra cull first and ask questions later, as proven by Geronimo the alpaca who didn't have TB	R1427. 11-20 chickens
	V	I understand why in a commercial setting but not a small set up at home. They are often pets and less or no more eggs post infection isn't an issue. We keep them for their personality so I'm less supportive.	R880. 11-20 chickens
	W	my kids are horrified that their pets could be executed	R1. 1-10 chickens
	X	our chickens are my sons (sic) pets	R275. 1-10 chickens
	Y	heartbreaking especially if your girls are pets	R887. 1-10 chickens
	Z	I would be devastated if I lost all my girls over one case	R904. 1-10 chickens

3. Results

3.1. Survey response and flock characteristics

In total, 1559 backyard poultry keepers responded to the survey. Of these, three sets of responses were excluded from further analysis for being incomplete (two sets) or completed by a non-UK respondent (one set). Of the remaining 1556 respondents, 1193 reported keeping chickens only, whilst 306 reported keeping chickens and other birds (see supplementary file Table S1).

In response to Q8, the majority of respondents reported keeping between 1 and 10 birds (1074 respondents) and the most frequent setting for backyard flocks was rural gardens (470 respondents) (see supplementary file Table S2). Most backyard birds kept by survey respondents were 'bought in' (a total of 1091 mixed and purebred birds), with 838 keepers categorising their birds as rescued; respondents could select more than one option and 253 respondents kept a mix of bought and rescued birds (see supplementary file Table S3).

3.2. Awareness and sources of information and support

Awareness of the 2021 outbreak of avian influenza was very high (99%). Among the sources of information, Table 2 shows that the majority of respondents (53%) heard of the outbreak from social media. The main organisations providing information to respondents included Defra (49.7%), British Hen Welfare Trust (33.8%) and the APHA (22.0%).[1] Information access does not necessarily mean keepers are able to understand and interpret the guidance it contains, however. A total of 1437 keepers (92.4%), were aware of their legal obligation to register their flock on the GB Poultry Register if they have 50 or more birds, which allows the APHA to contact them in the event of a disease outbreak in their area. It is possible to sign up to the Register voluntarily, and 82.4% of keepers were aware of this.

Table 2
"Where did you get this information?" (Follow-up to "Have you heard of the recent outbreak (November 2021) of Avian Influenza and the control measures you need to implement as part of the mandatory housing order?"). Base: 1559 adults self-defining as small-scale keepers, 4 December – 31 March 2022.

Source	Number of keeper respondents (%)
Social media	803 (53.0%)
Poultry register communication	260 (17.2%)
The internet	272 (17.9%)
Local vets	32 (2.1%)
Poultry keeper magazine	14 (0.9%)
TV	11 (0.7%)
Radio	6 (0.4%)

[1] Other organisations mentioned by keepers were Fresh Start for Hens (66 keepers), RSPCA (26 keepers) and the NFU (31 keepers).

3.3. Familiarity with clinical signs of HPAI

The corpus linguistic analysis of Q17 revealed that keepers, especially those with fewer birds, were often confused or unsure about the signs of HPAI with some reporting that they would 'look up' (e.g., R102) "symptoms" online if their birds appeared to be unwell (0.6%). Others responded with question marks or tentatively listed symptoms, followed by a question mark (e.g., 'sneezing'?), or responded 'not sure' (1.6%) or 'no idea' (0.6%). Many used vague language rather than reporting signs, including 'unwell' (11.0%), 'illness' (8.7%), 'ill' (6.5%) and 'sick' (4.2%). Some keepers with small flocks felt that their familiarity with the behaviours of individual birds would aid detection of HPAI symptoms: 'I know each bird in my flock and feel secure that I could tell if one was unwell' (R7, 21–50 chickens).

These findings suggest that many keepers with smaller flocks do not have an established understanding of clinical signs of HPAI. Clinical signs that were correctly identified by some include respiratory distress: 'cough[ing]' (5.7%); 'respiratory [problems]' (11.1%); 'lethargy' (9.1%); and 'loss of appetite' (3.7%). Around a quarter of keepers identified death as a sign (e.g., 'death' (12.9%), 'dead' (4.6%), 'deaths' (3.1%), 'dying' (1.9%), 'died' (1.0%), 'mortality' (0.6%), 'die' (0.4%)), 28.4% of whom used the phrase 'sudden death' (111 of 391 instances). Clinical signs communicated by Defra but rarely mentioned by keepers include tremoring (0.2%), haemorrhages ('bleeding' (0.1%)), loss of balance (0.7%), and increase in body temperature (0.1%). Behaviour or habit changes including 'depression' (1.7%), 'sneezing' (10.2%), 'discharge' (5.0%), 'blue' comb and wattles (4.9%), and 'swelling' (8.6%) were less often cited by keepers, as was reduction in egg production (2.8%).

Some keepers indicated that they distrusted authorities (e.g., "Not tell anyone, because otherwise DEFRA (sic) will bother you, and kill the rest. Keep quiet', R950, 1–10 chickens) and would not take action following suspected avian influenza in their flocks ('[do] nothing' 2 keepers with 21–50 chickens, 1 keeper with a mixed flock of 51–100 chickens, ducks, turkeys, geese and game birds). A minority of keepers suggested inappropriate and ineffective ways to treat the disease themselves, indicating that they would use Baytril (Enrofloxacin, a broad-spectrum antibiotic), apple cider vinegar, or F10 disinfectant, whilst others were dismissive of the seriousness of HPAI ('idiots at Defra over reacting -again', R775, 21–50 chickens, ducks and game birds; 'Absolutely a load of rubbish millions of wild birds and only a few cases of avion (sic) flu', R1494, 21–50 chickens, ducks and quail). The lack of trust is likely to make elimination of the virus in the UK extremely difficult.

3.4. Compliance with housing measures and biosecurity guidance

When asked about the accommodation of their birds when not under housing order restrictions, the most popular choice from the closed question options was "Confined at night, free range during the day" (46.9%), followed by "Coop and run" (41.5%), "Garden/field (free range)" (5.3%) and "Coop and run and free range" (2.8%). The most common types of coop material were wood (59.3%) and plastic (35.1%). More keepers described their coops as 'fixed' (12.8%) than 'portable' (7.9%). Many keepers reported that their standard housing prior to restrictions allowed access for both small and large birds to come into contact with their flock, including most commonly robins (46.8%), sparrows (45.7%), crows (33.7%) and pigeons (32.8%).

Corpus linguistic analysis of Q14 revealed further insights on keepers' understanding of mandatory housing order requirements. Keepers who were aware of the mandatory housing order understood that it was necessary to implement two main control measures, both of which were in line with Defra biosecurity guidelines. The first, keeping birds, food and water covered over and away from wild birds, was the most prevalent in their responses, extracts from which can be seen in Table 3. Here, keepers' responses frequently contained the words and phrases 'under cover' (15.0%, e.g., see extract A), 'cover[ed]' (40.8%, e.g., see extract B), 'confin[ed]' (3.7%), 'enclos[ed]' (9.6%), 'indoors' (4.0%), 'apart' (0.5%), 'separate' (4.0%) and '[not in] contact' (19.0%) in relation to wild birds. In addition, responses about wild birds contained 'minimise' (1.0%, 5 instances of which co-occur with wild birds, e.g., see extracts C, D, E in Table 3) and 'prevent' (9.7%, over 50 instances of which co-occur with 'wild bird(s)'). The negatives 'no' and 'not' also appear in this context alongside the words 'access [to wild birds]' (6.6%), 'contact [with wild birds]' (6.0%) and 'free range' (6.0%). Keepers, particularly those with low numbers of birds, also use language connoting permission ('allow', 'approve', 'let'), usually in relation to keeping wild birds away and limiting free range activities (see extracts F, G, H in Table 3 for examples). This indicates that keeping poultry away from wild birds is the most recognised requirement under the guidelines.

The foregoing responses align with Defra biosecurity guidelines, which state that 'wild birds' should be kept out of 'poultry buildings and feed stores' (Defra, 2022). A low number of keepers mentioned 'mesh' (12 instances; 0.8%) in relation to their bird housing (e.g., [I have] 'built a solid roofed, fine-*mesh* fenced area' that is approximately '20 m by 2 m outside the coop', R1123, 1–10 chickens). These are acceptable sizes according to Defra (2022), although the types of mesh mentioned by keepers varies.

The second main control measure highlighted by respondents was keeping themselves and facilities clean; 'hygiene' appeared 40 times and was usually modified by adjectives such as 'strict', 'stringent', or 'good'. There was also a strong focus on having extra clothing and footwear (e.g., see extracts I, J, K in Table 3) and the use of 'footbaths' (0.4%), and 'disinfectant' (4.9%, mainly used in relation to 'feet' 'shoes' and 'boots').

It is not always clear that keepers understand the measures to be implemented. For instance, the word 'Bio[security]' appears frequently (111 instances; 7.1%) but typically without elaboration (e.g., 'implement bio security measures', R40, 1–10 chickens; 'strict bio security measures must be in place', R53, 1–10 chickens). Moreover, some respondents explicitly highlighted their lack of understanding over what is required of them generally, and in relation to specific measures (e.g., extracts L, M, N in Table 3), whilst others incorrectly believed they had no action to take (e.g., extract O) or were unaware of whether biosecurity information was regulation or guidance (e.g., extract P), suggesting that there is room for improvement in communicating requirements to backyard keepers.

When asked to rate how easy they found it to make adjustments to comply with the housing order, just 3% of keepers said the measures were 'impossible' to comply with. The main reasons keepers gave for not complying with the measures were: expense; lack of labour or resources; concerns over bird welfare; short notice of the housing order; and poor weather conditions.

3.5. Perspectives on obligatory culling

Corpus linguistic analysis of Q19 highlighted that for many keepers, the issue of obligatory culling is highly emotive, as some of the extracts in Table 3 demonstrate. Words connoting 'mental processes' (Halliday, 1985; Halliday and Matthiessen, 2013) (i.e., those of perception, affection, and cognition) such as 'hate', 'dislike', 'loathe', 'agree', 'think', 'feel', and 'believe' are prominent in responses about this issue. The word 'think' is used to preface disagreement with obligatory culling of all birds in a flock with a case of avian influenza (e.g., extracts Q-S in Table 3). The predominant view of obligatory culling is that it is 'sad but necessary' ('sad' appears 255 times, 'necessary' appears 376 times and 'sad' collocates with 'but' 189 times), suggesting a generally pragmatic view for most keepers. Less frequently, keepers indicated that obligatory culling was 'sensible' (1.0%) or 'reasonable' (0.3%) or that they 'agree' (4.4%) with the measure, whilst others were 'unsure' (1.2%) about culling. Some mentioned that obligatory culling could cause reluctance to report suspected cases (e.g., extract T). Crucially, those with smaller

flocks often felt the approach was not suitable for the backyard context (e.g., extracts U-V).

Understandably, some keepers expressed extreme sadness at the death of animals they view as pets or family members (e.g., extracts W-Z). Words like 'heartbreaking/heart breaking' (2.1%), 'tragic' (0.5%), 'traumatic' (0.2%), 'extreme' (1.3%), 'harsh' (2.6%), 'awful' (0.9%), 'disgusting' (0.6%), 'horrible' (0.4%), 'unpleasant' (0.3%) and 'horrific' (0.2%) were prevalent in response to this issue. Such responses underline an urgent need for tailored sensitive communications for backyard keepers.

3.6. Perspectives on vaccination

As Table 4 shows, most survey respondents reported that they would be willing to vaccinate (1449 keepers; 93.1%) and of these, 410 keepers (26.3%) would be willing to pay between £ 0.01 and £ 2.50 per dose, 459 (29.5%) said that they would be willing to pay between £ 2.50 and £ 5, and 580 (37.3%) stated that they were prepared to pay higher costs. Following training from their vet, 602 keepers (38.7%) said that they would be prepared to vaccinate their birds themselves. Others felt confident in administering the vaccine themselves without training (36.5%) and some keepers stated that they would prefer their vet to vaccinate the birds (21.0%).

4. Discussion

In the UK, as in many other countries, the lack of information on small-scale poultry keepers and their awareness of and willingness to comply with recommended biosecurity practices hinders infectious disease surveillance and the implementation of HPAI-related control measures (Ayala et al., 2022; Conan et al., 2012; Correia-Gomes and Sparks, 2020; Elkhoraibi et al., 2014; Irvine, 2015; Jewitt et al., 2023; Karabozhilova et al., 2012; Sultana et al., 2012). This examination of the understanding and responses of small-scale poultry keepers in relation to HPAI has highlighted issues surrounding the knowledge and implementation of legally enforced avian influenza control measures. Although respondents indicated high levels of awareness of HPAI compared to data from studies undertaken in the USA (Elkhoraibi et al., 2014; Ayala et al., 2022), they indicated limited knowledge of recommended biosecurity measures and the potential for HPAI and other poultry diseases to be transmitted to humans and other animals, including household pets (Paphitis et al., 2023; Tobin et al., 2015). These findings echo those from other UK-based studies (Correia-Gomes and Sparks, 2020; Karabozhilova et al., 2012), as well as research undertaken in Italy (Di Giuseppe et al., 2008), where fewer than half of the backyard keepers surveyed had no detailed understanding of avian influenza transmission and hygiene practices despite receiving detailed information; and Egypt where disposal of dead birds and faeces in domestic refuse was found to be a significant H5N1 risk factor as free-range chickens could gain access (Sheta et al., 2014). This is in contrast with Burns et al. (2013), who found that Canadian keepers' knowledge and engagement with avian influenza information was generally high, but they were less likely to be compliant because they did not feel that local measures (e.g., pre-emptive culling) were appropriate for their context; and Olsen et al. (2005), who found that although knowledge of poultry handling practices among backyard keepers in Thailand was high (70%), for many, this did not translate to a change in practices. Comments by respondents that they were 'housing' their poultry in family homes offer a compelling illustration of the need for clear messaging for small-scale keepers and indicate that they misunderstood either the housing measure requirements or the risks to themselves and their pets from poultry-related diseases. Alternatively, in line with the attitudes of Burns et al.'s (2013) study of backyard flock owners in Canada, it could reflect UK keepers' attitudes towards chickens as pets or companion animals, other species of which typically share people's homes.

Our findings suggest that avian influenza biosecurity communications for backyard keepers are currently inadequate and although other factors are at play, such as the ongoing wild bird outbreaks, such issues will undoubtedly contribute to difficulties in the control of avian influenza in the UK. The following areas for improvement are highlighted in the survey responses: (i) messaging must reach keepers; (ii) the information they receive must bridge key knowledge gaps as well as being accessible; and (iii) tailored guidance is needed for small-scale and 'pet' keepers.

4.1. Reaching keepers

Our survey revealed that social media is the preferred source of avian influenza update information for backyard poultry keepers. It is therefore important that this channel of information is utilised by agencies responsible for communicating avian influenza guidance to concerned parties. On the other hand, some owners believe that there is a lack of mainstream news coverage of the disease. Lack of television and radio coverage may hinder the ability of those without access to social media platforms to comply with biosecurity guidance. The government website, email communication from the Poultry Register and the APHA's Facebook pages all provide updates about outbreaks and new protection and surveillance zones, but these sources require internet access and digital literacy skills. Others have noted the benefits of face-to-face public dissemination of scientific guidance (e.g., see Burger and Waishwell, 2001 on fish consumption advisories) for improving efficacy, and dialogue and discussion and promote public knowledge, enthusiasm, and trust in science communications (Varner, 2014). Though the avoidance of public panic is obviously desirable, it is essential that the public are apprised of relevant information via a range of channels if backyard keepers are to contribute to managing the spread of HPAI. This is especially important in light of keepers' occasionally negative sentiment towards Defra, particularly surrounding attitudes towards obligatory culling, fear of losing pets, and scepticism over the level of risk that HPAI presents.

Avian influenza is clearly an emotive issue for backyard keepers, and distrust of government agencies may affect willingness to voluntarily sign up to the poultry register, which in turn results in less direct communication with poultry keepers concerning outbreaks and reduced compliance. According to Wilson et al. (2017), scientists must understand which sources are most used and trusted by their audience for science communication to be effective. Our respondents clearly view vets as a trusted source as the majority would contact their vet in the event of a suspected avian influenza case in their flock.

Table 4
"If a vaccine were to become available for Avian Influenza which may mean that some of the control measures could differ from the current methods used (e.g. mandatory housing), would you vaccinate your chickens? If so, how much would you be willing to pay per dose, not including other veterinary fees?" Base: 1559 adults self-defining as small-scale keepers, 4 December – 31 March 2022.

	Cost per single vaccine dose						
	would not pay	£ 0 to £ 2.50	£ 2.50 to £ 5	£ 6 - £ 10	£ 11 - £ 15	£ 15 - £ 20	£ 20 +
No of respondents (%)[1]	107 (6.9%)	410 (26.3%)	459 (29.5%)	265 (17.0%)	76 (4.9%)	79 (5.1%)	160 (10.3%)

Note: [1] Proportion computed as a percentage of all respondents (n = 1556)

4.2. Bridging knowledge gaps and improving accessibility of information

The lack of knowledge of the clinical symptoms and signs of HPAI among keepers is concerning. High mortality is an important telling sign of the disease in chicken flocks, with death occurring within a few days after the onset of clinical signs (Alexander, 2007; Saif et al., 2011), but only 25.0% of keepers listed synonyms of 'death'. A follow-on workshop provided our survey respondents with a platform to raise their concerns and share ideas for improvement (Jewitt et al., 2023). Workshop discussions highlighted concerns over jargon (e.g., 'haemorrhages'), which caused confusion for keepers. Such findings highlight the need for more accessible information about the clinical signs of HPAI and resources describing the clinical signs in non-technical terms would be particularly beneficial. Moreover, discussions around obligatory culling should recognise that many keepers of smaller backyard flocks view their birds as pets or as part of the family. This underlines a need for a more sensitive approach to communicating this topic than would be used for commercial keepers.

Keepers understood the basic biosecurity measures that needed to be implemented such as covering food and water and maintaining high levels of hygiene. However, no keepers mentioned pressure washers, hoses or water per the official guidance to have "pressure washers, brushes, hoses, water, and fresh supplies of a government approved disinfectant available at all points where people should use them" (Defra and APHA, 2015). There were also few mentions of attempts to keep animals other than wild birds ('rodents', 16 instances; 'cats', 2 instances) away from their flocks despite this appearing in Defra's biosecurity guidelines. This reflects findings from other UK-based research on small-scale poultry keepers (Correia-Gomes and Sparks, 2020; Karabozhilova et al., 2012), which showed a lack of implementation of biosecurity measures for backyard flocks due to keepers being poorly informed on the topic.

Respondents' attitudes towards vaccination may indicate a lack of awareness of the practicalities of administering a vaccine as information on this was not provided in the survey. Some may have been under the impression that an HPAI vaccine could be given in water or as a spray, as with other poultry vaccinations, though it is likely that it would need to be injected (Defra and APHA, 2021). This may account for the high confidence that keepers expressed about administering the vaccine. It is therefore crucial that efforts to close potential gaps in understanding of stakeholder perspectives are taken to avoid assumptions and ultimately support greater compliance with biosecurity measures or other controls.

4.3. Tailored guidance for backyard and 'pet' keepers

There is a marked difference between the knowledge and resources of backyard flock keepers and those of large commercial situations. Indeed, cost—both in general and as a result of damage from adverse weather conditions—was a key reason keepers gave for not adhering to the housing measures. Tailored information with easy-to-implement, low-cost methods to adhere to biosecurity measures would be useful for backyard keepers. In addition, the following factors should be considered: where backyard flocks come from (most birds are bought in, i.e., not homebred); the ease of wild bird access to the poultry if protection measures are not implemented (the majority of backyard birds are allowed to free range during the day when housing measures are not in place, increasing opportunities for contact with wild birds); the numbers of urban backyard birds, which potentially pose a greater risk of zoonotic spread than rurally kept backyard flocks; and the common materials keepers use to house their birds (most are housed in wooden coops, which are difficult to disinfect). These are all high-risk factors for avian influenza entering a backyard flock and should be addressed in tailored guidance for backyard keepers. One output from this study seeks to address this by providing guidance to keepers in animation format (University of Nottingham, 2023).

4.4. Methodological limitations

As the survey was advertised on social media, online forums or distributed by email, those without access to the internet or online groups are not represented in these present findings, whilst those who seek or share information about their poultry online are likely to be over-represented. However, internet coverage across the UK is widespread and households without at least mobile internet access are rare; 98% of the UK population had internet access in 2023 (Statista, 2023). This is reflected in the locations of survey respondents, some of which were from remote locations (e.g., the Orkneys) as shown in Fig. 1. Non-English speaking poultry keepers in the UK are also not represented in the results. The dissemination of the survey during an active avian influenza outbreak that received widespread social media coverage is likely to have enhanced respondents' awareness of the mandatory housing measures and biosecurity requirements above what might be expected at other times. Regular discussions of avian influenza in the groups that disseminated the survey may also have increased awareness of or concern about HPAI among their members. As participation in the survey was particularly high among ex-commercial hen re-homing group members, who often regard their poultry as pets, the results may overestimate the knowledge and compliance of the wider poultry-keeping community.

5. Conclusions

A large nationwide survey representing over 1550 poultry keepers – the largest survey of its type yet reported – highlights significant barriers to the future control of HPAI in the UK. The results indicate that not all backyard poultry keepers have been implementing the biosecurity measures outlined by the government under the avian influenza housing order measures, either due to a lack of awareness of what is required of them or factors such as expense, lack of manpower, bird welfare, short notice of the housing order and poor weather conditions. These factors need to be taken into consideration and advice should be tailored specifically to backyard keepers as well as commercial units. The advice for what is expected of backyard keepers needs to be affordable, realistic and achievable and any technical jargon it contains must also be explained in lay terms. The information should have the most important measures highlighted, along with some reasoning and it needs to be available via multiple modes of communication.

The most common source of avian influenza information is social media, which could further be exploited. However, it is important to consider that some keepers may be limited by lack of internet and digital literacy skills and may not access the government website or governing body social media pages. Communication via mainstream news channels could be improved, which would also help increase public awareness of the disease. This is important from the perspectives of both avian and human health. Clinical signs, especially sudden death/high mortality, which is characteristic of HPAI, need to be widely communicated to poultry keepers along with clear steps to follow if they suspect an avian influenza case. There is a high risk that backyard keepers may not report suspected HPAI cases due to misunderstanding or lack of knowledge of the clinical signs of HPAI, as well as fears over obligatory culling. Obligatory culling acts as a deterrent to reporting a suspected case and fuels mistrust of government agencies (Scott et al., 2004) although vets are seen as a trustworthy source and are the most common first port of call in a suspected outbreak of HPAI in a backyard flock and testing is available to exclude HPAI as a potential cause of disease (APHA, 2019).

More work is needed to ascertain whether the messaging has improved understanding in the 2022–23 avian influenza season, as well as in future years. The issues mentioned in this paper threaten hopes of eliminating HPAI in the UK and beyond, as well as presenting wider threats to public health, wild bird populations and the poultry sector more generally. Solutions will require close collaboration between government agencies, veterinarians, researchers and different types of

poultry keepers with specific emphasis on the development of messaging and guidance tailored specifically for small-scale and non-commercial flock owners.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.prevetmed.2024.106117.

References

Alexander, D.J., 2007. An overview of the epidemiology of avian influenza. Vaccine 25 (30), 5637–5644.
APHA 2019. Testing for exclusion of notifiable avian diseases. ⟨http://apha.defra.gov.uk/vet-gateway/tte/nad.htm⟩. (Accessed 31 May 2023).
APHA. 2021. Livestock Demographic Data Group: Poultry population report. [Report]. APHA. ⟨http://apha.defra.gov.uk/documents/surveillance/diseases/lddg-pop-report-avian2020.pdf⟩. (Accessed 4 November 2023).
Ayala, A.J., Haas, L.K., Williams, B.M., Fink, S.S., Yabsley, S.S., Hernandez, M.J., M, S., 2022. Risky business in Georgia's wild birds: contact rates between wild birds and backyard chickens is influenced by supplemental feed. Epidemiol. Infect. 150 https://doi.org/10.1017/S0950268822000851.
Bavinck, V., Bouma, A., van Boven, M., Bos, M.E.H., Stassen, E., Stegeman, J.A., 2009. The role of backyard poultry flocks in the epidemic of highly pathogenic avian influenza virus (H7N7) in the Netherlands in 2003. Prev. Vet. Med. 88, 247–254.
Burger, J., Waishwell, L., 2001. Are we reaching the target audience? Evaluation of a fish fact sheet. Sci. Total Environ. 277 (1–3), 77–86. https://doi.org/10.1016/S0048-9697(00)00864-0.
Burns, T.E., Ribble, C., McLaws, M., Kelton, D., Stephen, C., 2013. Perspectives of an underrepresented stakeholder group, backyard flock owners, on poultry health and avian influenza control. J. Risk Res. 16 (2), 245–260.
Chen, H., Li, Y., Smith, G.J.D., Li, K.S., Wang, J., Fan, X.H., Rayner, J.M., et al., 2006. Establishment of multiple sublineages of H5N1 influenza virus in Asia: implications for pandemic control. Proc. Natl. Acad. Sci., USA 103, 2845–2850.
Conan, A., Goutard, F.L., Sorn, S., Vong, S., 2012. Biosecurity measures for backyard poultry in developing countries: a systematic review. BMC Vet. Res. 8, 240. ⟨http://www.biomedcentral.com/1746-6148/8/240⟩.
Correia-Gomes, C., Sparks, N., 2020. Exploring the attitudes of backyard poultry keepers to health and biosecurity. Prev. Vet. Med. 174, 104812 https://doi.org/10.1016/j.prevetmed.2019.104812.
Defra and A.P.H.A., 2015. Disease prevention for livestock and poultry keepers. ⟨https://www.gov.uk/guidance/disease-prevention-for-livestock-farmers⟩. (Accessed 11 April 2023).
Defra and APHA, 2023b. Welfare of Housed Birds. https://www.gov.uk/guidance/bird-flu-avian-influenza-housing-your-birds-safely#welfare-of-housed-birds (Accessed 18 April 2023).
Defra and APHA, 2021. Avian influenza (bird flu) vaccination. https://www.gov.uk/government/publications/avian-influenza-bird-flu-vaccination/avian-influenza-bird-flu-vaccination (Accessed 12 November 2022).
Defra, 2022. Biosecurity and preventing welfare impacts in poultry and captive birds. Advice for all captive bird and poultry keepers (including game birds, waterfowl, and pet birds). https://www.gov.wales/sites/default/files/publications/2022–10/biosecurity-and-preventing-welfare-impacts-in-poultry-and-captive-birds-update.pdf (Accessed June 2022).
Defra. 2023. National statistics. Livestock populations in England at 1 June 2023. [Report]. Defra. https://www.gov.uk/government/statistics/livestock-populations-in-england/livestock-populations-in-england-at-1-june-2023#:~:text=The%20female%20breeding%20flock%20fell,by%201.1%25%20to%2032%20million (Accessed 4 November 2023).
Di Giuseppe, G., Abbate, R., Albano, L., Marinelli, P., Angelillo, I.F., 2008. A survey of knowledge, attitudes and practices towards avian influenza in an adult population of Italy. BMC infectious diseases 8, 1–8.
Elkhoraibi, C., Blatchford, R.A., Pitesky, M.E., Mench, J.A., 2014. Backyard chickens in the United States: a survey of flock owners. Poult. Sci. 93, 2920–2931 https://doi.org/10.3382/ps.2014-04154.
European Commission, 2023. Animal diseases: Commission adopts harmonised rules on vaccination of animals. https://www.pubaffairsbruxelles.eu/eu-institution-news/animal-diseases-commission-adopts-harmonised-rules-on-vaccination-of-animals/ Accessed (Accessed 24 March 2023).
Farm Advisory Service. 2021. Poultry Factsheet - chickens. [Report.] FAS. https://www.fas.scot/downloads/poultry-factsheet/. (Accessed 4 November 2023).
Food and Agriculture Organisation, 2023. Global Avian Influenza Viruses with Zoonotic Potential situation update. https://www.fao.org/animal-health/situation-updates/global-aiv-with-zoonotic-potential/en (Accessed 11 April 2023).
Freath, L., Pacey, A., Gale, P., Perrin, L. 2022. Highly pathogenic avian influenza (HPAI) in the UK and Europe. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1055942/hpai-europe-number14–14-feb-2022.pdf (accessed 12 December 2022).
Gillings, M., Mautner, G., Baker, P., 2023. Corpus-Assisted Discourse Studies, first ed. Cambridge University Press,. https://doi.org/10.1017/9781009168144.
Halliday, M.A.K., 1985. An Introduction to Functional Grammar, firstst ed. Edward Arnold,, London.
Halliday, M.A.K., Matthiessen, C.M., 2013. Halliday's Introduction to Functional Grammar. Routledge,.
Hamilton-West, C., Rojas, H., Pinto, J., Orozco, J., Hervé-Claude, L.P., Urcelay, S., 2012. Characterization of backyard poultry production systems and disease risk in the central zone of Chile. Res. Vet. Sci. 93 (2012), 121–124. https://doi.org/10.1016/j.rvsc.2011.06.015.
Indrawan, D., Rich, K.M., Van Horne, P., Daryanto, A., Hogeveen, H., 2018. Linking supply chain governance and biosecurity in the context of HPAI control in Western Java: a value chain perspective. Front. Vet. Sci. 5, 94 https://doi.org/10.3389/fvets.2018.00094.
Irvine, R.M., 2015. A conceptual study of value chain analysis as a tool for assessing a veterinary surveillance system for poultry in Great Britain. Agric. Syst. 135, 143–158. https://doi.org/10.1016/j.agsy.2014.12.007.
Jewitt, S., Smallman-Raynor, M., McClaughlin, E., Clark, M., Dunham, S., Elliott, S., Munro, A., Parnell, T., Tarlinton, R., 2023. Exploring the responses of smallscale poultry keepers to avian influenza regulations and guidance in the United Kingdom, with recommendations for improved biosecurity messaging. Heliyon. https://doi.org/10.1016/j.heliyon.2023.e19211.
Karabozhilova, I., Wieland, B., Alonso, S., Salonen, L., Hašler, B., 2012. Backyard chicken keeping in the Greater London urban area: welfare status, biosecurity and disease control issues. Br. Poult. Sci. 53, 421–430. https://doi.org/10.1080/00071668.2012.707309.
Kilgarriff, A., Baisa, V., Bušta, J., Jakubíček, M., Kovář, V., Michelfeit, J., Rychlý, P., Suchomel, V., 2014. The sketch engine: ten years on. Lexicography 1 (1), 7–36.
Kyle, C., & Sutherland, L.A. , 2018. Understanding backyard poultry keepers and their attitudes to biosecurity. Report published on EPIC website. https://www.epicscotland.org/media/1559/final-report-smallflocks-and-biosecurity.pdf.
Linden, J. 2022. Europe pushes for acceptance of HPAI vaccination. Watt Poultry. https://www.wattagnet.com/articles/45210-europe-pushes-for-acceptance-of-hpai-vaccination (Accessed 13 November 2022).
McClaughlin, E., Vilar-Lluch, S., Parnell, T., Knight, D., Nichele, E., Adolphs, S., Clos, J., Schiazza, G., 2023. The reception of public health messages during the COVID-19 pandemic. Appl. Corpus Linguist. 3 (1), 100037.
MRCVSonline, 2020. Chicken ownership on the rise, survey reveals: https://mrcvs.co.uk/en/news/19529/Chicken-ownership-on-the-rise,-survey-reveals (accessed 12/06/23).
Oliver, I., Roberts, J., Brown, C.S., Byrne, A.M., Mellon, D., Hansen, R., Banyard, A.C., James, J., Donati, M., Porter, R., Ellis, J., Cogdale, J., Lackenby, A., Chand, M., Dabrera, G., Brown, I.H., Zambon, M., 2022. A case of avian influenza A(H5N1) in England, January 2022. Eur. Surveill. 27.
Olsen, S.J., Laosiritaworn, Y., Pattanasin, S., Prapasiri, P., Dowell, S.F., 2005. Poultry-handling practices during avian influenza outbreak, Thailand. Emerg. Infect. Dis. 11 (10), 1601.
Paphitis, J., Devon Metcalf, D., Weese, S., 2023. Backyard chickens — a cross-sectional survey of current and prospective backyard chicken owners in Ontario (2019–2021). Can. Vet. J. 64 (1), 54–62.
Rayson, P. 2008. From key words to key semantic domains. International Journal of Corpus Linguistics. 13:4 pp. 519-549. DOI: 10.1075/ijcl.13.4.06ray.
Rayson, P.E., 2003. Matrix: a statistical method and software tool for linguistic analysis through corpus comparison. Lancaster University (United Kingdom).
Rimi, N.A., Sultana,. Ishtiak-Ahmed, K., Haider, N., Azziz-Baumgartner, E., Nahar, N., Luby, S.P., 2018. Where backyard poultry raisers seek care for sick poultry: implications for avian influenza prevention in Bangladesh. BMC Public Health 18, 969. https://doi.org/10.1186/s12889-018-5819-5.
Saif, Y.M., Fadly, A.M., Glisson, J.B., McDougald, L.R., Nolan, L.K., Swayne, D.E., 2011. Diseases of Poultry, twelveth ed. Wiley,, London.
Scott, A., Christie, M., Midmore, P., 2004. Impact of the 2001 foot-and-mouth disease outbreak in Britain: implications for rural studies. J. Rural Stud. 20 (1), 1–14.
Shao, W., Li, X., Goraya, M.U., Wang, S., Chen, J.L., 2017. Evolution of influenza a virus by mutation and re-assortment. Int. J. Mol. Sci. 18 (8), 1650.
Sheta, B.M., Fuller, T.L., Larison, B., Njabo, K.Y., Ahmed, A.S., Harrigan, R., Chasar, A., Aziz, S.A., Khidr, A.A.A., Elbokl, M.M., Habbak, L.Z., 2014. Putative human and avian risk factors for avian influenza virus infections in backyard poultry in Egypt. Vet. Microbiol. 168 (1), 208–213.
Sims, L.D., 2013. Intervention strategies to reduce the risk of zoonotic infection with avian influenza viruses. Influenza Other Respir. Virus 7 (Suppl 2), 15–25.

Sims, L. D. 2008. Poultry in the 21st Century: Avian Influenza and beyond. Risks associated with poultry production systems. Food and Agriculture Organisation. https://www.fao.org/3/i0323e/i0323e02.pdf Accessed 22nd January 2024.

Smallman-Raynor, M.R., Cliff, A.D., 2008. The geographical spread of avian influenza A (H5N1): panzootic transmission (December 2003–May 2006), pandemic potential and implications. Ann. Assoc. Am. Geogr. 98, 553–582. https://doi.org/10.1080/00045600802098958.

Smith, G., Dunipace, S., 2011. How backyard poultry flocks influence the effort required to curtail avian influenza epidemics in commercial poultry flocks. Epidemics 3 (2), 71–75. https://doi.org/10.1016/j.epidem.2011.01.003.

Statista. 2023. Internet usage in the United Kingdom (UK) https://www.statista.com/topics/3246/internet-usage-in-the-uk/. (Accessed 10 November 2023).

Stibbe, A., 2012. Animals Erased: Discourse, Ecology, and Reconnection with the Natural World. Wesleyan University Press,, Connecticut.

Sultana, R., Rimi, N.A., Azad, S., Saiful Islam, M., Salah Uddin Khan, M., Gurley, E.S., Nahar, N., Luby, S.P., 2012. Bangladeshi backyard poultry raisers' perceptions and practices related to zoonotic transmission of avian influenza. J Infect Dev Ctries 6 (2), 156–165.

Sultana, R., Rimi, N.A., Azad, S., Islam, Saiful, Khan, M.Salah Uddin, Gurley, M., Nahar, E.S., Luby, N., S.P, 2012. Bangladeshi backyard poultry raisers' perceptions and practices related to zoonotic transmission of avian influenza. J. Infect. Dev. Ctries 6 (2), 156–165.

Tenzin, T., Wangdi, C., Rai, P.B., 2017. Biosecurity survey in relation to the risk of HPAI outbreaks in backyard poultry holdings in Thimphu city area, Bhutan. BMC Vet. Res. 13 (1), 113.

The Poultry Club. 2024. Breed Clubs. https://www.poultryclub.org/resources/poultry/breed-clubs/ Accessed 22nd January 2024.

Tiensin, T., Chaitaweesub, P., Songserm, T., Chaisingh, A., Hoonsuwan, W., Buranathai, C., Parakamawongsa, T., Premashthira, S., Amonsin, A., Gilbert, M., Nielen, M., Stegeman, A., 2005. Highly pathogenic avian influenza H5N1, Thailand, 2004. Emerg. Infect. Dis. 11, 1664–1672.

Tobin, M.R., Goldshear, J.L., Price, L.B., Graham, J.P., Leibler, J.H., 2015. A framework to reduce infectious disease risk from urban poultry in the United States. Public Health Rep. 120 (4) https://doi/10.1177/003335491513000417.

UK Government, 2022. Human case of avian flu detected in UK https://www.gov.uk/government/news/human-case-of-avian-flu-detected-in-uk (Accessed 10 November 2022).

UK Government, 2023a. Poultry (including game birds): registration rules and forms. https://www.gov.uk/government/publications/poultry-including-game-birds-registration-rules-and-forms (accessed 25 April 2023).

UK Government, 2023b. Highly pathogenic avian influenza in Great Britain: evaluation and future actions. https://www.gov.uk/government/publications/highly-pathogenic-avian-influenza-in-great-britain-evaluation-and-future-actions/highly-pathogenic-avian-influenza-in-great-britain-evaluation-and-future-actions (accessed 18 April 2023).

University of Nottingham. 2023. Avian Flu, what a poultry keeper needs to know | School of Veterinary Medicine and Science. Available at: https://www.youtube.com/watch?v=LSIJJXMyXFk. (accessed 7 November 2023).

Varner, J., 2014. Scientific outreach: toward effective public engagement with biological science. BioScience 64 (4), 333–340. https://doi.org/10.1093/biosci/biu021.

Wilson, M.J., Ramey, T.L., Donaldson, M.R., Germain, R.R., Perkin, E.K., 2017. Communicating science: sending the right message to the right audience. FACETS 1 (1), 127–137. https://doi.org/10.1139/facets-2016-0015.

Xu, X., Subbarao, K., Cox, N.J., Guo, Y., 1999. Genetic characterization of the pathogenic influenza A/Goose/Guangdong/1/96 (H5N1) virus: similarity of its hemagglutinin gene to those of H5N1 viruses from the 1997 outbreaks in Hong Kong. Virology 261, 15–19.