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Preventive, safety and control measures against Avian Influenza A(H5N1) in occupationally exposed groups: A scoping review

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ABSTRACT

Introduction: During the outbreak of avian influenza, A (H5N1) (IA) in wild and domestic birds recorded in January 2023, the epidemiological alert has been extended due to its potential contagion to humans, particularly in those exposed occupational groups.
Objective: to identify the primary occupational risk groups, as well as the preventive, safety, and control measures against IA intended or implemented in these positions.
Material and methods: A systematic search was conducted in Pubmed, Scopus, Web of science, Scielo and literature databases. Scientific articles, normative documents, and technical reports identifying vulnerable occupational groups and preventive measures against IA were included. Two authors conducted a full-text review, extracting information independently, and findings were summarized narratively.
Results: A total of 5518 documents were identified, and 30 reports were included. 20% of the reports were published in 2023, 13/30 were affiliated to a university institution. Occupationally exposed groups were identified both directly and indirectly. 63.3% of reports identified breeders, poultry farmers and sellers as the most concerning occupational group, while 60% identified biosecurity practices (use of PPE, handwashing) as the primary measure against IA, followed by strategies such as education (training and capacity-building).
Conclusion: Occupational groups of interest were identified, primarily those involved in sales, commerce, and the handling of bird waste with potential exposure to IA. Furthermore, the maintenance of biosecurity measures, cleaning-disinfection practices, and educational strategies in workplace settings are recommended.

1. Introduction

Influenza Aviar (AI) or avian flu, caused by the A (H5N1) virus, primarily affects avian species, leading to economic consequences [1,2]. While outbreaks have been recorded in the European poultry sector, with a notable impact in Britain [3], its spread is attributed to the migratory movement of infected wild birds [4]. This has resulted in its expansion in the northern and southern hemispheres since 2020, posing a threat to wild bird ecosystems [5].

Zoonotic type A (H5N1) viruses rarely transmit from person to person. However, documented cases of human transmission exist. An example occurred in Hong Kong in 1997, with an outbreak in poultry leading to 18 human infections [6], and in Southeast Asia in 2003, spreading to other continents such as Europe, Asia, and Africa [7]. Since then, the World Health Organization (WHO) has expressed concern about the potential human infection, reporting a total of 868 cases of (H5N1) in 21 countries, with a high fatality rate (53%) resulting in 457 deaths [8]. Additionally, recent search indicates changes in the transmission mechanisms of the virus. Particles implicated in the virus spread are primarily biological aerosols ($\leq$5 μm), and droplets (>5 μm) [9]. Moreover, evidence suggests these particles can spread short distances (<10 m) through the air and travel between 50 m and 80 m [10], raising concerns about possible transmission between farms and homes.

In 2023, a significant event occurred with the identification of the first human case of A (AH5N1) infection in Ecuador [10]. By, the end of February 2023, 17 outbreaks of AI had been reported in commercial poultry farms and backyard birds [10]. Additionally, an outbreak of AI caused by clade 2.3.4.5 was recorded, significantly impacting poultry and wild birds [11]. Consequently, on March 13, 2003, the Pan American Health Organization (PAHO) issued an alert in the Americas region, recommending the strengthening of surveillance for respiratory diseases in animal and human populations [12]. As long as AI circulates among birds, there is a risk of human infection [12]. The most common transmission route occurs through direct and indirect contact with infected

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birds and exposure to contaminated elements, such as fomites or surfaces and environments contaminated with feces. Any activity involving the handling, cleaning, or plucking of birds intended for consumption represents a significant risk factor [13].

In this context, certain occupational groups face a higher risk of AI virus transmission, including farmers and poultry breeders [14], bird sellers in markets [15], personnel responsible for animal health, and even beach cleaning staff. These risks are notably higher in countries with lower economic incomes, where overcrowding and animal control measures are less stringent [16]. WHO recommends that workers who have been in contact with these animals and present respiratory symptoms seek immediate medical attention and remain in isolation [17]. However, there is a currently lack of information on preventive, safety, and control measures implemented against AI in these groups, posing a serious concern for the health and safety of workers in high-risk occupations.

2. Material and methods

2.1. Revision

This review aimed to identify the preventive, safety and control measures against the highly pathogenic avian influenza (HPAI), AI onwards, primarily targeting occupational groups at risk or occupational exposed, as well as the main promoting entities. These objectives align with the original protocol; however, we added the question: what factors are related to the use/implementation and success of these measures in occupational exposed groups? This allowed for a more comprehensive exploration of the included articles [18].

2.2. Study design

This review followed the Joanna Briggs Institute guidelines for Scoping review [19]. A protocol was designed a priori and registered on the OSF platform, available at: https://osf.io/hgkma/. Additionally, the report was carried out following the comprehensive PRISMA extension for Scoping Review (PRISMA-ScR) guidelines [20].

The Participant, Concept, and Context (PCC) framework was adopted to develop eligibility criteria. Occupationally exposed workers were considered the population of interest, including farmers, poultry breeders, bird sellers, workers in the poultry industry, veterinary personnel, and those involved in beach cleaning. The context is set during the outbreak of influenza AI in various countries worldwide, affecting wild and domestic birds with potential contagion to humans. Further details on eligibility criteria are provided in Supplementary Material S1 available at: https://osf.io/7f3zx. Source types included scientific articles and gray literature, with publications in both English and Spanish. There were no date restrictions for the sources of evidence.

2.3. Search strategy

A Search strategy (available in supplementary material S2: https://osf.io/7f3zx) was developed based on MeSH, emtree, and free terms, adapted to databases including PubMed, Scopus, Web of Science, Scielo and gray literature. The strategy included technical documents, prevention Guidelines, and implementation guides from governmental and private entities. Terms such as Poultry[Mesh], "poultry worker*", "live bird market", "Influenza A Virus", "H5N1 Subtype", Prevention, safety and control measures: surveillance "prevent* measure*", "control measure", "outbreak investigation*", "support measure", PPE, "environmental adjustment*", "education*" initiative, "work arrangement*", among others were included. The search was executed on September 17, 2023.

2.4. Study selection and data extraction

Reports were initially imported into Zotero (https://www.zotero.org/). Duplicates were removed before importing articles into the Rayyan software (https://www.rayyan.ai/), where reviewers HCS and LCA conducted pilot test before the title and abstract screening. Differences were resolved through consensus between reviewers. Subsequently, we independently reviewed the full-text content of articles and external documents to determine eligibility criteria for inclusion in the study. Finally, and experienced reviewer (LCA) verified the integrity and accuracy of the extracted data.

The resulting studies were included for the next stage of information extraction. Before this, a data extraction form, validated by the authors, was designed. All conflicts were arbitrated by LCA. The extraction tool was modified to include a column for factors related to the use and implementation of prevention, control, and mitigation measures in the population.

2.5. Data analysis and presentation

The information was extracted into an Excel spreadsheet, including data such as author, year of publication, document type (technical document, guide), study type (observational: cross-sectional, cohort, case-control), qualitative studies, mixed studies, year of study execution, and results: characterization of strategies and related factors.

2.6. Ethical considerations

This study received approval from the Institutional Ethics and Research Committee of the Universidad Cesar Vallejo, under code: Dictamen 096-CEI-EPM-UCV-2023.

3. Results

A total of 5512 articles and 6 government documents were identified. Following the selection process and criteria, 30 reports were included in this review Fig. 1.

3.1. Characteristics of the studies

We identified 30 reports related to preventive, surveillance, and control measures for AI in occupational risk groups. Among these, 6 (20%) were published in 2023. Additionally, 13out of 30 reports had a university-affiliated institution as the primary affiliation of the first author. It is noteworthy that only 8 out of 30 works had funding for their execution, and of these, 6 out of 8 came from public institutions or organizations. Furthermore, the observational design was the more frequently reported (19 out of 30). See Table 1.

Finally, the countries with the highest number of studies were the USA, Nigeria and Indonesia, each with 2 out of 30 reports. In contrast, countries such as Hong Kong, Switzerland, Ghana, and Vietnam each presented only one report, details in Fig. 2. A timeline analysis of founded studies and the global trends, policy changes and outbreaks are showed in Supplementary material (S3).

3.2. Occupational groups

Table 2 identifies the occupational groups addressed in the reviewed scientific articles and documents. Out of the total, 6 out of 30 (20%) focused on implementing measures workers involved in bird slaughter and plucking [21,22], landfill workers [23], collection [24], processing of infected animal carcasses, and outbreak response [25,26]. These activities were organized as part of the AI outbreak control process in their respective countries.

Among the occupations causing greater concern, 63.3% (19/30) of the total cases analyzed involve commercial breeders [27–32], backyard

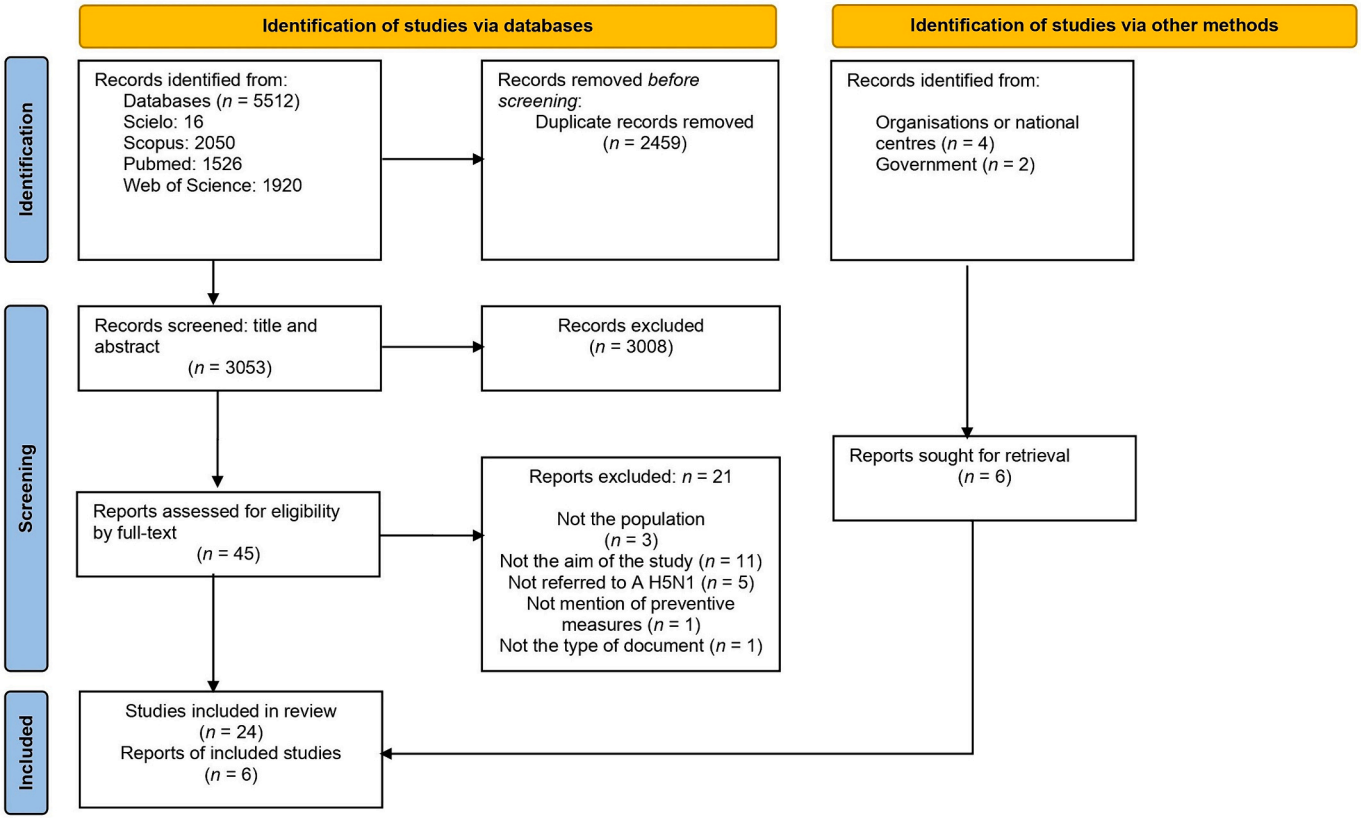

Fig. 1. PRISMA flowchart of selected studies.

Table 1
Characteristics of selected documents and articles.

Characteristics of the studies	n	%
Yeas of publication		
2007	1	3.3
2009	2	6.7
2010	2	6.7
2011	5	16.7
2013	1	3.3
2014	2	6.7
2015	3	10.0
2016	1	3.3
2017	2	6.7
2018	1	3.3
2019	1	3.3
2020	3	10.0
2023	6	20.0
First author affiliation		
University	13	43.3
Research group	2	6.7
CDC	6	20.0
International agency	2	6.7
National/international organization	6	20.0
Armed forces	1	3.3
Funding		
Yes	8	26.7
Public institution	6	75.0
Non-profitable organization	2	25.0
No	9	30.0
No reported	13	43.3
Study design/type of study		
Cross-sectional	19	63.3
Case report	3	10.0
Qualitative	1	3.3
Experimental	1	3.3
Other (guideline, technical report)	6	20.0

N = 30

poultry farmers [7,29,33–36], bird sellers in markets [31,34,37–39], and poultry farmers in general [40,41]. These individuals play a crucial role in the breeding, marketing, and distribution of birds, exposing themselves directly to health risks due to the close interaction and handling of birds carrying the AI strain.

Additionally, studies by Paudel et.al and Hossain et.al [21,42] not only addressed the involvement of poultry sector workers but also evaluated the possible implication of butcher workers in the spread of AI. Furthermore, the critical importance of having human health professionals such as doctors and nurses [23,32,42–44], and properly trained veterinarians [29] in prevention and biosecurity measures [36,45]. These professionals are key elements in communication strategies, serving as fundamental sources of information for the public. Finally, other studied groups include farmers, representing 10% (3/30) [23,44,46], military personnel [47], hunters [32], inspection personnel, as well as professionals responsible for wildlife shelters and bird guano management [23].

The Fig. 3 shows a graphical summary of the main occupational groups identified according to their direct and indirect exposure and the identified AI measures. The first category identifies three subgroups: Handling live birds in trade and breeding, waste handling and segregation, and healthcare personnel. The second category identifies indirectly exposed occupational groups such as military personnel, local authorities, hunters, and inspection personnel.

3.3. *Surveillance, control and preventive measures*

In relation to preventive, surveillance and control measures, it is notably that the primary strategy focused on the maintenance, evaluation, and monitoring of biosecurity measures. This involved the use of PPE such as gloves, aprons, coveralls, googles, mask, respiratory protectors, handwashing, boots, and footwear. This specific measure was

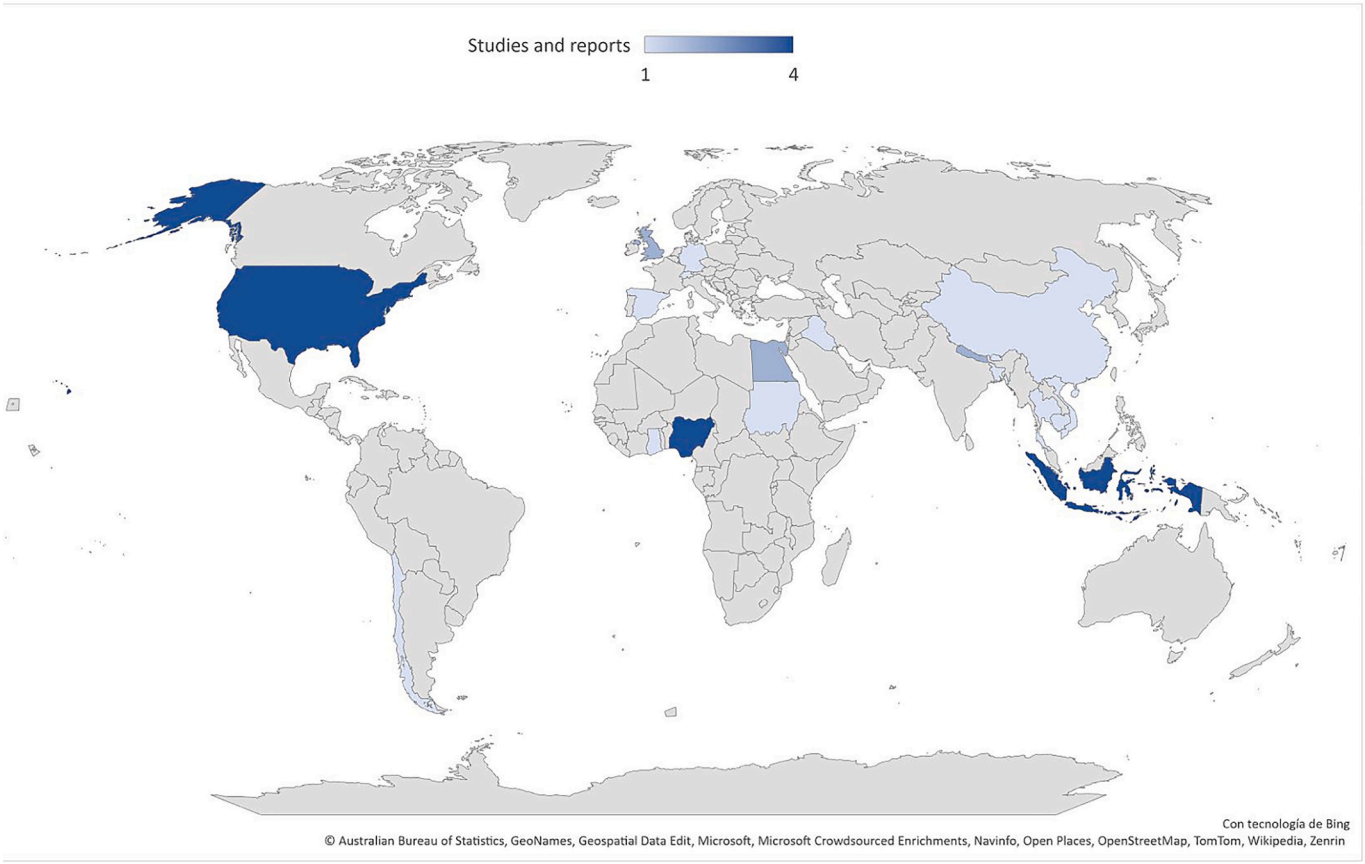

Fig. 2. Geographical distribution of studies and reports.

identified in 60% of the reports [7,21–25,29,31–33,36,39–42,44,46,47]. Various Authors concur on promoting the implementation of biosecurity measures based on risk identification, the application of specific preventive measures, and continuous monitoring over time.

Additionally, cleaning and disinfection of environments [7,21,28,37,38,40,41,47], instruction in handling dead birds, knowledge of symptoms and signs of AI contagion, as well as training in care practices [21,29,36,42,44,47] remain essential measures to mitigate the spread of contagion in exposed workers. Added to these actions are informative strategies disseminated through media such as TV, radio and graphic materials in 13.3% (4/30) of the reports [29,30,33,35]. In addition vaccination [22,27,28,32,43,46] and prophylaxis [22,25] are highlighted as measures directed at workers at risk, and as control measure, the home isolation of already exposed workers [32,46].

On the other hand, surveillance measures have been implemented, such as early detection of the virus in markets [34], symptom monitoring [32], notification, and contact tracing [23,30]. These practices are presented as common and effective in addressing the challenges related to preventing AI contagion in high-risk occupational groups. Table 2.

3.4. Factors related to implementation

Characteristics associated with the success or failure of the implementation of these measures have been identified. Various authors maintain that a higher level of education, literacy [21], opinions of technical experts, healthcare personnel [28], being a farmer with field experience [33], as well as a better disposition towards government regulations [29], access to surveillance systems, and ease of use [29,34] were common factors associated with the success of acceptability and implementation of these measures.

Conversely, a poor level of education [21,37], low vaccine acceptance rate [27], fear of adverse vaccine effects [43], distrust of information [30], poor knowledge [31], the trade of birds and other species in the same space [39], hinder the adoption of these measures. The distribution of main barriers and facilitators for AI prevention per country is shown in supplementary material (S4 and S5).

4. Discussion

The outbreaks of AI recorded in Asian, European, and more recently, American nations have alerted global healthcare systems, given the potential threat they pose to human health [8]. In response to this situation, countries such as Spain [22], Chile [23], and the USA [32] have implemented specific protocols aimed at the prevention and control of AI, particularly focusing on vulnerable occupational groups. Among these are poultry farmers [27,40,41], bird breeders [28–33,35,36,45,48], sellers [31,34,37–39], healthcare personnel involved in sample collection [32,43,44], individuals dedicated to animal life control [29,32,36,44,45], and workers responsible for the disposal of birds deceased due to AI [22–25]. This review identified studies that describe and/or implement various measures in vulnerable groups, with the majority coming from higher education institutions, supported by public agencies and non-governmental organizations, followed by local documents. Primarily, conducted in a research context rather than as a public health policy.

The main identified strategies focus on promoting, preventing, and protecting the health of workers against the threat of AI contagion. Crucial measures, such as strengthening biosecurity practices [21,25,33], including handwashing [31,32,40,41]and the use of PPE [24,25,32,40], are essential to safeguard workers handling birds in confined environments. Although the transmission of AI to humans is unlikely, both authors and institutions strongly endorse the recommendation of using PPE as a preventive measure. Despite the

Table 2
Summary of Prevention, Surveillance, and control measures against Avian influenza in exposed occupational groups.

Author, year	Country	Execution period	Occupational group	Prevention, surveillance and control measures	Factors Associated with the Implementation of Measures	Ethic committee
Paudel, 2023 [21].	Nepal	June–July 2012	Butchers, workers involved in the slaughter, plucking, and cutting of poultry	Education: Understanding AI Prevention: Personal protection - use of aprons, handwashing, gloves, masks, boots, and goggles.	Facilitator: Age > 25, literacy, and higher education level. Barriers: Primary education	Research Ethics Committee of the Institute of Medicine at Tribhuvan University, Nepal
Gumilang Pramuwidyatama, 2020 [48].	Indonesia	No reported	Small-scale commercial bird breeders	Prevention: Routine cleaning and disinfection. Vaccination, reports on sanitary culling	Facilitator: Expert opinions, veterinary personnel, and technical advisors from animal health companies influence the adoption of preventive measures.	no reported
Vivancos, 2011 [27].	United Kingdom	No reported	Poultry workers in commercial poultry facilities	Vaccination programs	Barriers: Low vaccination rate (7%–29%) and limited acceptance among poultry workers	no reported
Josette S Y Chor,2009 [43].	Hong Kong	January–March 2009, May 2009	Healthcare workers (nurses, doctors, allied health workers)	Vaccination A (H5N1)	Facilitator: age < 30 years, for being a doctor, having received prior influenza vaccination, perceiving a higher risk of contracting influenza, and a belief that influenza and pandemics could seriously affect their lives. Barrier: Fear of adverse effects, doubts about its efficacy.	The survey and behavioral Research Ethic Committee of the Chinese University of Hong Kong
Nicol Coetsse, 2011 [25].	United Kingdom-England	February–November 2007	Workers in an industrial processing plant for infected poultry carcasses	Prevention: Pre-exposure prophylaxis (oseltamivir 75 mg/day for 10 days), seasonal influenza vaccination, use of PPE (face shield, FFP3 mask, respirators, goggles, gloves, boots, helmets, splash-proof suits). Handwashing, reporting symptoms up to 2 weeks after the last exposure	No reported	no
Ghada Nasr Radwan, 2011 [33].	Egypt	February 2007	Housewives who raise and do not raise birds	Prevention: Information through mass media (TV, radio, friends, and relatives). Identification of sources of contagion and biosecurity measures in bird breeding)	Facilitator: Being a farmer, employee, bird breeder, having fear of AI infection, positive attitude towards government regulations. Barrier: Lower educational level of the husband	no
Xun Lei [37].	China	October 2015–January 2016	Bird sellers in markets	Prevention: Weekly cleaning and disinfection of bird cages and equipment	Facilitator: Being older, having a higher level of education, having worked for a long time	Medical Ethics review Committee of CQMU
Jeffrey C. Mariner [29].	Indonesia, Sub-Saharan Africa, Republic of south of Sudan, Egypt	January 2006	Backyard poultry keepers, commercial breeders, livestock veterinarians	Education and communication through visual materials, historical narratives, puppetry. Surveillance: Community engagement	Facilitator: Easy access to the surveillance system and surveillance personnel. Barrier: Community restrictions due to contagion fears	No
Ndadilnasiya Endie Waziri [34].	Nigeria	February 2006–November 2008	Live-bird traders	Surveillance: Virus detection in bird markets	Facilitator: Simplicity and flexibility of use	No
J.Saurina [30].	Switzerland	August–December 2007	Commercial and non-commercial poultry breeders	Prevention: Information through media, Surveillance: Contact	Facilitator: Perceived need for more prevention and	No

(*continued on next page*)

Table 2 (*continued*)

Author, year	Country	Execution period	Occupational group	Prevention, surveillance and control measures	Factors Associated with the Implementation of Measures	Ethic committee
				tracing and breeding practices.	protection information. Barrier: Distrust in information through media and veterinarians	
Gina Samaan [38].	Indonesia	No reported	Market managers and poultry breeders	Prevention: Cleaning, disinfection, waste segregation. Surveillance: Monitoring systems and regulatory practices.	No reported	Health research Ethics Committee at the National University Human Research Ethics committee
O.I Musa, S.A [35].	Nigeria	No reported	Poultry breeders	Prevention: Infection information through media: TV, radio	Facilitator: Interest in receiving public awareness campaigns and home visits. Barrier: Belief that bird deaths are an annual phenomenon.	No
Tenzin Tenzin [49].	Bhutan	24–27 April 2015	Poultry breeders	Prevention: Biosecurity measures in poultry farming, handwashing, use of soap and water after handling poultry products, mask usage, glove usage, and cleaning of breeding grounds	Barrier: Lack of access to the daily use of PPE (Personal Protective Equipment)	No
Atta Ah Mousa Al Sarray [31].	Iraq	1 November 2017–30 November 2018	Poultry breeders and bird sellers in the market	Prevention: Handwashing, glove usage after handling sick or dead birds, mask usage	Barrier: poor level of knowledge	No
Prince Godfred Agbenohevi [47].	Ghana	5–29 March 2012	Military personnel	Educational: Training on biosecurity measures, cleaning, disinfection, and handling of live/dead birds; avoiding contact with birds during feeding	No reported	Institutional review board of Noguchi Memorial Institute for Medical Research
Olubunmi G, Fasanmi [39].	Nigeria	February and May 2015	Sellers of live birds in the market	Prevention: Assessment of biosecurity levels in live bird markets	Facilitator: Good habits such as handwashing after bird slaughter and routine cage and door disinfection. Barrier: Trade of live birds and other species	No
Farrell PC [44].	Vietnam	November and December 2011.	Farmers, semi-commercial farmers, village animal health workers, village human health workers, and local authorities	Educational: Knowledge of AI clinical signs. Vaccination	Barrier: Irregular vaccination programs (limited access to vaccines for breeders due to poor distribution), underreporting due to lack of knowledge, and economic losses	University of Sydney Human Research Ethics Committee (14234) and the Hanoi School of Public Health Institutional Review Board.
Anastasia S. Lambrou [40].	Nepal	July and August 2018	Poultry farmers and agricultural workers	Prevention: Handwashing before and after entering the premises, change of PPE, use of gloves, masks, boots, or aprons. Disinfection at corral entrances. Change of clothing for visitors	Facilitator: Age over 18 and working at least one day a week in the task. Barrier: Lack of participation (8 farms refused to participate in the study)	Ministry of Agriculture and Forestry, Rampur, Chitwan District, Nepal, Institutional Review Board (IRB) at the Agricultural University"
Worapol Aengwanich [41].	Thailand	July–October 2013	Poultry farmers	Prevention: Wildlife protection, bird attraction measures, measures for farm staff, entrants, visitors, and buyers, including surface disinfection, footwear, vehicle disinfection, handwashing, and showers	Facilitator: Data/idea collection in brainstorming sessions. Barrier: Excessive investments that cannot be financed.	Research Ethics Committee of Maha Sarakhan University
Hossain SM (50).	Bangladesh	January–April 2012	Poultry workers, butchers, and sanitation workers	Educational: Implementing health programs. Preventive: Best practices to ensure proper training	Facilitator: Information about AI through electronic media and reminders of good biosecurity practices	Local Committee (no detailed)

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Table 2 (*continued*)

Author, year	Country	Execution period	Occupational group	Prevention, surveillance and control measures	Factors Associated with the Implementation of Measures	Ethic committee
Akinola A. [45].	Nigeria	September 2007	Poultry breeders (families) and animal health personnel	Prevention: Intervention in preventive measures, project monitoring model, knowledge in biosecurity measures and infections related to AI	Facilitator: Washing and disinfection of surfaces and body, bird vaccination. Barrier: Limitation of the study environment, as several poultry centers are not registered	No
Dilip P. [36].	Cambodia	No specified	Families engaged in poultry farming, and animal health personnel	Educational: Training for animal health personnel and information on the causes and symptoms of AI disease	No reported	No
Wei Cai [24].	Germany	February–March 2006	Personnel involved in the collection of dead birds	Preventive: The use of masks, gloves, protective glasses, and PPE, along with serological tests	Barrier: Difficulty in mobility with the use of PPE, glasses, mask, and clothing	Charité Ethics Commission, Universitäts Medizin Berlin, and the Responsible Data Protection and Freedom of Information Commission of the German Federal Government and the State of Mecklenburg-Western Pomerania
Dikky Indrawana [46].	West Java (Indonesia)	September–October 2016	Agricultural workers	Prevention: Isolation, fencing, entry blocking, facility cleaning, foot showers for farm entry, changing room, disinfection, and cleaning	Facilitator: Supervisory visits to farms (cleanliness), analyzing through direct observation and real-time interviews.	Animal health agency and Ethics committee at the center of animal tropical Studies IPB
USA Fish & wildlife office.(51).	USA	2023	Hunters	Preventive: Avoid contact with dead and sick birds, handwashing, and alcohol use. Wear rubber footwear, keep hunting tools clean and disinfect (with a chlorine solution). Use latex gloves, avoid introducing food or drinks while handling birds. Separate raw meat in a container away from cooked food, cook game meat at a temperature of 73.8 °C. Dispose of waste in separate bags.	No reported	No
CDC USA [26]	USA	2023	Poultry outbreak response personnel	Control: Monitoring symptoms for 10 days after contact exposure, RT-PCR testing, active monitoring for those without PPE use, and passive monitoring for those with PPE use. Home isolation if symptoms are present, notification if any symptoms occur. Preventive: Use of PPE.	No reported	No
CDC USA Agriculture department [32].	USA	2023	Poultry producers	Preventive: Use of PPE, masks, boot covers. Ventilate the environment, handwashing with soap and water, Dispose of PPE after use, Boot disinfection. Regular training, Do not share supplies with other owners, Establish a	No reported	No

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Table 2 (*continued*)

Author, year	Country	Execution period	Occupational group	Prevention, surveillance and control measures	Factors Associated with the Implementation of Measures	Ethic committee
				perimeter between the farm and the home.		
CDC USA Agriculture department [32].	USA	2023	Healthcare providers	Preventive: Collect samples according to protocol recommendations. Advocate for the use of PPE, gloves, handwashing, and goggles. Reprocessing of reusable medical equipment, surface disinfection.	No reported	No
Ministry of Health-Chile [23]	Chile	2023	Worker involved in the collection and burial of dead birds or other infected animals, Worker responsible for landfilling animals suspected of avian influenza (AI), Worker collecting samples from dead or suspected AI-infected birds or animals, Worker overseeing facilities with avian influenza outbreaks, Worker involved in poultry farms, Worker in wildlife shelters or zoos in contact with birds or their waste, Worker handling guano from birds, Worker on a farm managing birds or other animals	Preventive: Use of PPE: rubber gloves, eye protection, protective clothing against chemical and infectious agents of type 5 and 6, safety footwear. Control: Proper supervision of PPE, Respiratory protection with filter: N95, FFP2. Surveillance: Tracking exposed individuals, attending to suspected cases, rest or medical leave for 7 days, follow-up on confirmed cases"		No
Ministry of Health, Social Services, and Equality; Ministry of Agriculture, Fisheries, Food and Environment, 2017 [22]	Spain	2017	Workers in close contact: involved in animal slaughter or decontamination, farm personnel	Preventive: Pre-exposure prophylaxis (oseltamivir 75 mg 2v/day for 7 days), seasonal flu vaccination, risk information, use of PPE including disposable nitrile or vinyl gloves, industrial rubber gloves, FFP2 respiratory protection or surgical masks, protective goggles, use of waterproof protective clothing, disposable shoes or rubber boots. After work, individuals should shower		No

inconveniences reported by workers, such as difficulties in mobility [24], breathing, and the associated costs of acquisition [48], the importance of this practice is emphasized to safeguard occupational health in this context.

Regarding cleaning and disinfection, it has been noted that the disinfection process of spaces such as live bird markets significantly contributes to reducing the risk of contagion, both among birds and between birds and humans [28,37,38,40,47,48]. However, it is emphasized that the risk increases due to the fast-paced work, constant flow of buyers, and contact with fomites [9]. Consequently, the implementation of specific schedules, measures for entrants [41], and control of entry and exit flow, as well as ventilation [9], is recommended in these establishments as an effective measure to reduce contagion.

In relation to control, the literature mentions that, in previous outbreaks, culling birds represents a viable measure [39]. However, both commercial and domestic breeders express reluctance to this recommendation, mainly due to significant associated economic losses [44]. In response to this situation, various government institutions have established compensation systems to mitigate massive losses. Despite this, significant barriers persist, such as workers´ fear of not fully recovering their investment and the stigma associated whit these measures. These factors have triggered additional problems, such as underreporting of cases [44], non-participation [40], insufficient monitoring, and, therefore, a lack of reliability in surveillance systems.

In this same line, vaccination [27,28,43] and pre-exposure prophylaxis [22,25] are essential elements, particularly in the field of healthcare workers and those involved in the culling, cleaning, and handling of waste from infected birds [22,23]. The effective implementation of these measures is facilitated by factors such as age, higher education level, a sharper perception of health risk, affiliation with the health sector, and greater work experience, as identified [43]. However, obstacles as inadequate resource distribution, especially regarding access to vaccines, and the spread of misinformation represent significant challenges that threaten the effectiveness of these initiatives.

Among the highlighted strategies, education emerges as a fundamental tool that is deployed across various levels of exposure. Authors

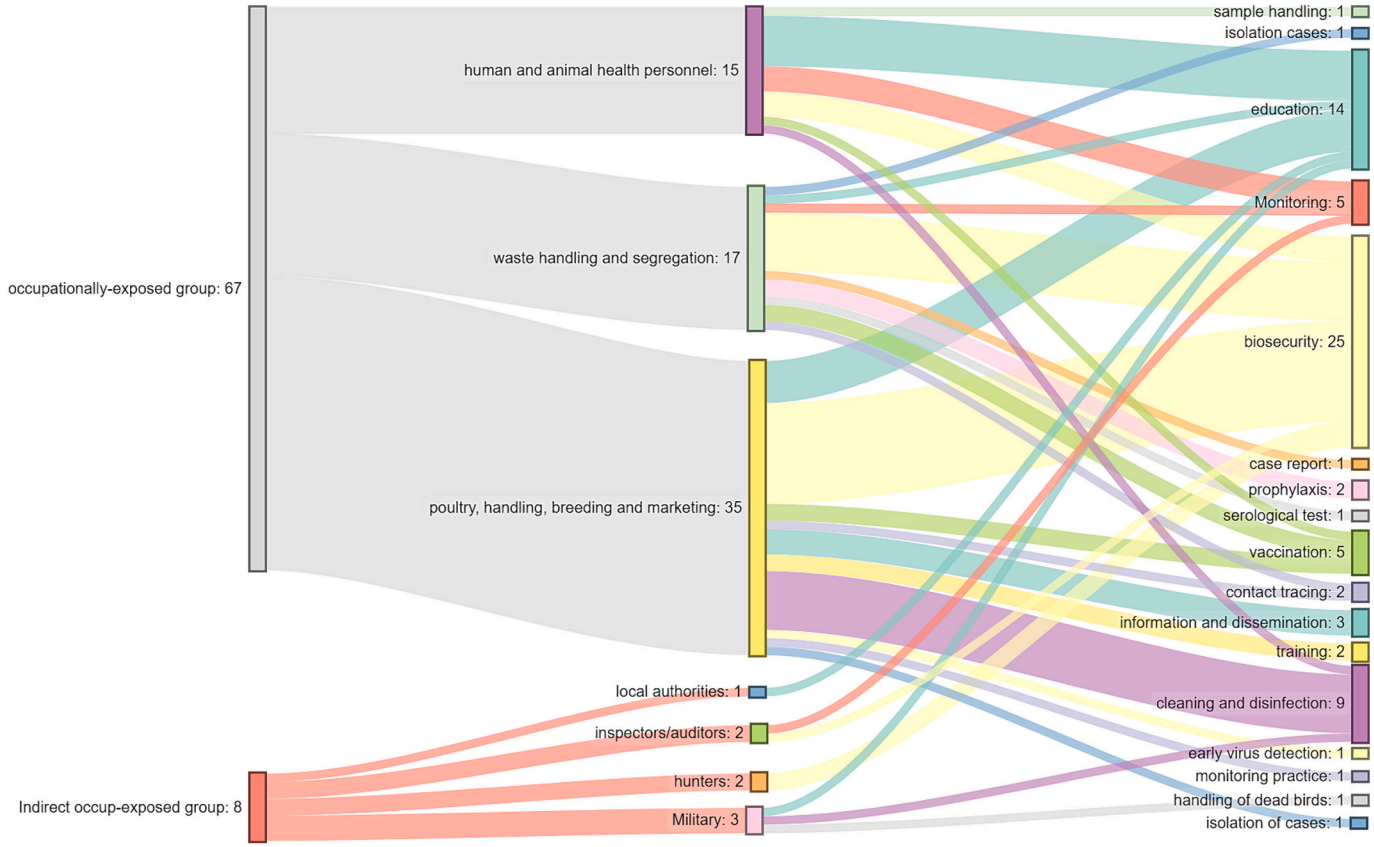

Fig. 3. Occupationally exposed groups and measures against AI.

such as Paudel et.al [21], Prince, et al. [47], Farrell et al. [44] y Akinola et al. [45] underscore the importance of and adequate level of knowledge in identifying signs and symptoms of AI contagion, as well as in the application of biosecurity measures and proper waste handling. In contrast,

Dilip et.al [36] suggests that providing specialized training would be a more effective measure in AI prevention, both in breeding communities and among healthcare personnel. Both perspectives are supported, as various reports indicate that staff training through graphic media and dissemination through media platforms such as TV and radio [35] are essential components for learning and the effectiveness of these measures, especially in rural contexts.

4.1. Limitations

This review aimed to explore measures targeted at occupational groups at risk of exposure to avian influenza (AI). The sources of the search were from both English and Spanish languages, which could pose a language barrier since Asian countries, where most AI outbreaks have occurred, may have technical documents in other languages. Although this study did not specifically address workers or breeders of bovine, it emphasizes the need of conducting further research in this area. The existing literature primarily focuses on avian species in the context of AI, while relatively little attention has been given to understanding the disease dynamics in bovines. Given the potential economic and public health implications of avian influenza, it is essential to broaden research efforts to include bovine populations. Investigating the susceptibility, transmission dynamics, and potential control measures of avian influenza in bovines can provide valuable insights into disease management strategies [49]. Moreover, considering the proximity of bovine to other livestock and humans, understanding the risk of interspecies transmission is critical for effective disease prevention and control measures. Therefore, future research initiatives should prioritize exploring the role of bovines in AI transmission and pathogenesis to develop comprehensive strategies for disease management and mitigation.

5. Conclusion

A significant portion of the identified documents has been developed within the context of scientific research by academic entities with non-governmental funding, focusing on occupationally exposed workers to avian influenza (AI). The primary highlighted measure is the application of biosecurity practices, with a focus on the provision and proper use of personal protective equipment (PPE). Following this, educational measures are emphasized, implemented through training and educational programs.

In the establishment of surveillance measures, the importance of vaccination and prophylaxis, preferably in healthcare personnel and poultry breeders, is highlighted. However, potential barriers to the successful implementation of these measures are identified, such as lower educational levels, the daily cost of using PPE, and the perception of a lesser need for protection against AI in certain contexts. Finally, it is worth mentioning that the adaptation of these measures according to the context, needs, and specific priorities of the occupational group plays a crucial role in reducing risk and preventing contagion in the workplace.

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Haydee Susana Catalan Saenz: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Liliana Cruz-Ausejo:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Data availability

No data was used for the research described in the article.

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