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STRATEGIC MANAGEMENT OF THE AVIAN INFLUENTZA (AI) / HIGHLY PATHOGENIC AVIAN INFLUENZA (HPAI)

Mirela Daniela NICOLA, Dorina Nicoleta MOCUȚA

University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Management, Economic Engineering and Rural Development, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: mireladanielanicola@gmail.com

Abstract

Avian Influenza (AI) is a contagious disease, first described in Italy, in 1878, by Peroncito, as a disease with high mortality in poultry, next documented as a type A influenza virus, in 1955, by Schäfer W., and then recognized as a transboundary disease spreading across international borders, occurring worldwide (consistent evidence support the transboundary character of the disease, particularly from 2003 to our days, in Asia, USA, Latin America, Europe, Oceania). Data available shows that AI has significantly affected the world economy and society in the last decades, causing disruption of poultry industry and global trade, changes in poultry industry and markets policies, affecting livelihood of vulnerable people, producing considerable control costs, and starting with 1997 it is also highly recognised as a public health threat that can cause illness or death in humans. Despite the new tools used by the modern management (advanced science technologies, statistics tools, etc.) the disease still leave behind losses into the global poultry industry and sometimes human deaths (Hong Kong, Cambodia, Djibouti, Egypt, Iraq, Turkey etc). The paper aims to review the knowledge on the management of AI (HPAI) in the world, to identify gaps or weaknesses in the management of the AI and to try to provide guidelines on how countries can be better organized to react to an outbreak of AI/HPAI and/or to identify better ways to diminish the devastating impact of the disease upon societies, consumer, trade between the countries, economy.

Key words: *animal health, crisis management, risk factors, economy trade JEL classifications: H12, Q18.*

INTRODUCTION

The article reviews the evidence available in relation to crisis and emergency management practices in respect of Avian Influence (AI) outbreaks in the world. Documented evidence show that it is a disease with history, first described in 1878, in Italy, by Peroncito [1,2], then confirmed in 1955 that is a Influence virus by *Schäfer* W. [1,2] and in 2003 recognized as a transboundary disease, spreading across international borders, occurring worldwide (consistent evidence support the transboundary character of the disease, in Asia, USA, Latin America, Europe, Oceania). Today evidence show that AI is still a problem with global impact which requires attention from all parties involved (government, scientists, industry, population).

In this context, the paper is reviewing the crisis management process implemented in case of AI outbreaks (the epidemiology of AI, the monitored data, the shortcomings and the gaps identified by different bodies or risk assessor – auditors of EC, EFSA researchers, OIE, FAO, WTO – international organisations etc) and the progress registered by different techniques to support crisis management (modelling, risk management, genotyping, mapping technique comparisons studies, etc) in the world, and different factors that influence the management of the AI virus (gaps in scientific information, shortcomings identified in the official animal health controls applied by the competent authorities, statistical approaches rather than biological evidence etc.).

MATERIALS AND METHODS

Retrospective method was used. Data collected, registered and notified to OIE, EC by countries, audit reports, reports issued by EC, FAO, OIE, official presentations, data published in various scientific articles concerning the AI were reviewed.

RESULTS AND DISCUSSIONS

During the last century the entire world experienced a large number of AI health crisis with politic, economic and social impact [1, 2, 8, 9, 11, 16, 17, 21].

Despite the negative impact of the crisis, markets changed, restrictive measures on trade, human deaths, they also left us to the world a measurable print, or legacy, respectively we learned from them around the clock.

In 1878, the AI was first time differentiated from the other diseases that cause high mortality rates in birds, by Perroncito E. [1]. 81 years later, over a period of 36 years (from 1959 to 1995), sources mention that 15 outbreaks of HPAI viruses were recorded in poultry (1) *They also, point out that at that time the AI was causing high mortality but the outbreaks were patchy and limited to small regions.*

However according to the data available, until 1997 (119 years later), when the *first human case was detected and reported in Hong Kong* [1,2] the poultry outbreaks were reported mostly globally.

In 1996, the H5N1 virus was found in China in a commercial geese and it was believed to originate from H5 viruses in wild migratory birds [12]. However, this outbreak gave rise in 1997 to the next outbreaks of H5N1 in the farms of Hong Kong and led to human infections and deaths. Surveillance revealed that H5N1 was widespread in poultry and the birds were culled.

Only after that moment the disease was propelled in the centre of attention of the whole world (scientists, officials, public), recognised as a public health concern and a transboundary animal disease and *monitored more carefully and systematically diagnosticated in the world. After that moment and based on the reported data it can be noticed that the AI outbreaks were rather frequently diagnosed and reported* (Figures 1, 2, 3).

During the next 10 years (from 1997 to 2007), literature recorded further 11 HPAI outbreaks in poultry. This time it was point out that some of them affected millions of birds and spreaded across Asia [10], Europe and Africa, in over 60 countries.

Europe experienced six major HPAI episodes, three of which occurred in the last years (2016-2017 [2, 9], 2017–2018 and 2019-2020 [6].

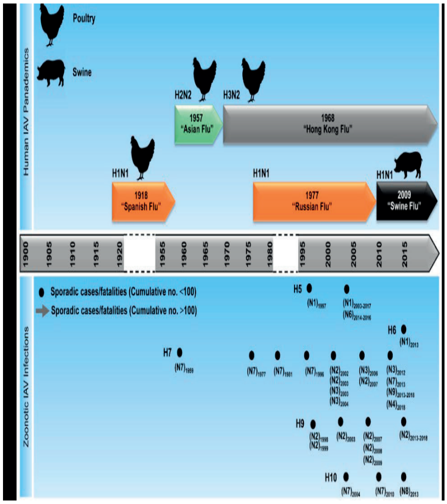


Figure 1. The timeline (1900-2015) of flu pandemics and epidemics caused by influentza A virus (authors Ahmed Mostafa, Elsayed M. Abdelwhab, Thomas C. Mettenleiter, and Stephan Pleschka)

Figure 2. The flu pandemics and epidemics caused by influentza A virus between 2016-2021 in Europe (serotypes identified H5N1, H5N3, H5N5, H5N6, H5N8, H5Nx) (Source: ADNS/DGAL/FAO/OIE)

Documented evidence [8] show that the avian influenza type A viruses appear *to be adapted very well in aquatic wild birds, in waterfall, gulls, shorebirds etc and also specify that the complete host range*[19] *for AI in wild birds is not completely know.*

We remind here also about the past pandemics when the non-human Influenza A viruses changed and infected people: in 1918 (when H1N1 – determined as an avian origin gene, however there is no universal consensus, and 50 million deaths worldwide were registered), in 1957-1958 (H2-N2 avian origin gene, when another 1.1 million deaths worldwide were

registered),in 1968 (H3-N2 avian origin gene as well, when 1.1 million deaths were registred worldwide,) and 2009 (H1-N1 virus – half a million death world wide),
Since then, studies have been conducted in the entire world, and revealed new scientific information, but also new gaps [Verhagen et al., 2021]. Partially the studies addressed problems and provided valuable knowledge to the world, but also recommended further research (for example the inclusion of new methodes such as whole genome sequencing, continuing on host identification and avian ecology and introducing the developments in the risk based surveillance of Avian Influenza [Verhagen et al.,2021].
In Europe in 2005, the European Commission and the World Bank hosted an international conference on AI and pledged million of euro to fight against AI with the experts of the Republic of China.
In 2015, EFSA organised, a workshop where it was analysed the state of knowledge, etiology and epidemiology of the IA virus in animals, the threats and the gaps:

I. targeting four major subjects:
- interaction host – pathogen (to understand host range restriction [18], to identify mechanisms by which viruses adapt to new host species),
- methods of diagnostics (improving the diagnostics, respectively developing more rapid molecular tests and early detection),
- surveillance and risk management (risk analyse of introduction the virus into EU, new risks tools),
- prevention (developing efficient vaccine and vaccination programme, to validate bio security measures) and control

II. mapping the AI EU projects funded by EU in last 10 years

III. Analysing and discussing:
- the status of knowledge on IA surveillance, monitoring and control,
- the transmission evidence for AI from animal to human and how was identified by the surveillance measures,
- the viral characteristics associated with animals AI virus and human infection,
- the epidemiological risk factors/and drivers connected with IA transmission and spreading between species, and within animal populations,
- the scientific gaps need it to be identify and address through research,
- how to rank a pandemic risk posed by a given AI virus.

At the end, they realised that at that time the understanding of the transmission of the virus intra and between animal species and from animals to humans, on host-range, drivers of virulence **was in fact basic**. They admitted that the standardisation of the diagnostic tools the integration of the databases and networks, as well as international cooperation are the keys to success. Also, they realised that there is a need to involve scientists from many sciences in order to achieve greater impact in AI management [13, 14].

They identified the needs, and set up the long and short goals. the objectives, and
- proposed a revised animal health framework based only on scientific science,
- prioritised the interventions related to prevention, preparedness in case of a crises, research and innovations programmes,

In this context, other new studies were initiated at molecular level [8,9], studies in the unexplored areas of immunology – in order to improve the vaccine responses, to create vaccines that can be mass-delivered and studies in epidemiology in order to clearly understand the modes and routes of transmission within and between animal species/ to humans, and studies of predictive biology, and mathematical modelling in order to predict and improve the overall management of the disease [13, 14], studies concerning the sampling methodology /test results of the surveillance programme carried out by Member States [1-21].
On the other hand, epidemiological and genetic comparison studies [13] were carried out by scientists in different countries between *the* 2016-2017 *episode* and the two previous episodes that took place in Europe (2005-2006 and 2014-2015) (source Comparison of 2016-2017 and Previous Epizootics of Highly Pathogenic Avian Influenza H5 Guangdong

Lineage in Europe). The study concluded that a record in Magnitude was registered in 2016-2017 and they underlined that they noticed significant variations between the episodes (temporal, spatial, epidemic curve, seasonality etc) concluding that is difficult to predict future HPAI epizootic. They also recommended global surveillance of the virus changes in order to provide valuable information for preparation, detection and control of HPAI.

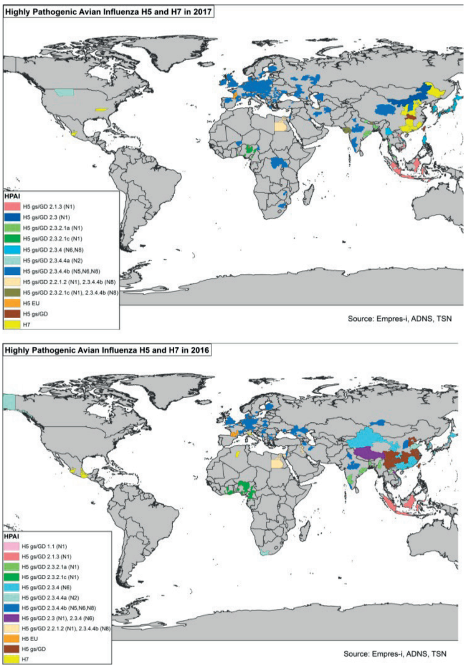
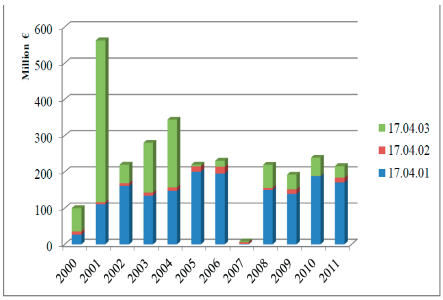


Figure 3. EFSA Journal, Volume: 15, Issue: 10, First published: 16 October 2017, DOI: (10.2903/j.efsa.2017.4991

Consecutive crisis, the CE/the other affected countries **drafted legislation**, carried out evaluation of the **entire/partial management control system** [3], **audits** [7], promoted collaboration, organised workshops, training reunited their forces in focused research etc.
One point of legislation everywhere require to draw up Contingency plan [5] which represent a management tool to help them to control operations (before, during and after unforeseen event) and return to its daily operations as quickly as possible after an outbreak /pandemic episodes.
The legislation foreseen a minimum set of requirements:

- cooperation between authorities & stakeholders /a chain of command and a coordinator unit called National Disease Control Centre,
- setting a Local Disease Control Center,
- detailed instructions concerning the controlling actions for addressing the outbreak, to protect the public and animal health and to reduce the negative effects,
- clear details on responsibilities staff established (who does what and when!),
- real time alert exercise,
- equipment & materials available any time,
- diagnostic labs facilities & capacity for rapid diagnosis,
- legal powers to ensure the implementation
- holding registration and identification of the high density areas that presents risks,
- emergency vaccination,
- a permanent operational expert,
- training,
- communication with the general public who directly /indirectly/ voluntary /involuntary participate in one way /another to the crisis management plan influencing the favourable /unfavourable implementation of the plan,
- access to financial resources.

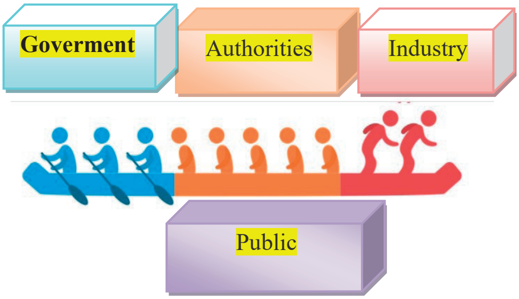
The EU co-financed the Member States Plans and veterinary emergency actions.



Note: Outturn payments are the sum of credits generated in a specific year.
Source: DG SANCO, based on financial decisions 1999-2011

Figure 4. EU Funding for Animal Health 2000-2011 (source - Evaluation of the EU rapid response network, crisis management and communication capacity regarding certain transmissible animal diseases, 01.08.2012)

However, based on documents reviewed and analysed (EC audit reports [7], FAO reports on AI) we can emphasize that cooperation between the key relevant stakeholders is a critical condition during the control/management of a disease, particularly in pandemic occurrences. They should act as one [13, 14].



One more frequent problem identified during audits [7] on the implementation of a crisis management plan is poor coordination of all the stakeholders listed above, reflected in the short-comings identified during the implementation of the actions planned, non effective and efficient use of resources, inconsistent protection of the public and animal health, and huge negative impact on economy, society, environment etc on long time.

An additional difficulty met in reality is that the decision makers have to overcome political, mass media, industry, and people pressures and to keep everybody happy, so to speak, to motivate them, to involve them in the process, to make them to understand and accept the unpleasant, unpopular and costly measures. Sometimes, the pressures influence their decision-making process and operations, affecting in the end the achievement of the targeted objectives. Pressures encourage on-going events that can cause general uncertainty and weaken the country control system put in place to defend the human and animal health.

In summary, in reality these goals listed above (collaboration, coordination, lack of pressure) are not so easy to achieve [7], and additionally there are also other many factors that can interfere in the implementation of the plan, such political instability, other interests, lack of government support and commitment to unpopular measures, illegal movements and trade of the domestic and wild birds, people culture (lack of trust, lack of education, poverty etc), climate and wild bird migration changes, competency of the veterinary authority etc

Phylogenetics analysis of the viruses brought information on the main paths in the world (see Figures 5, 6).

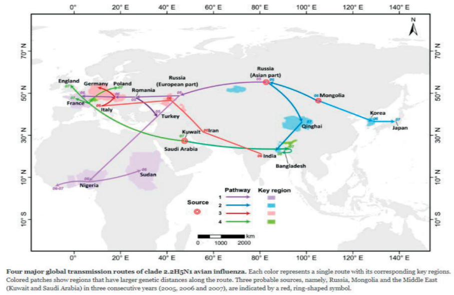


Figure 5. Major global transmission routes of H5N1 avian influenza. (source global spatiotemporal and genetic footprint of the H5N1 avian influenza virus, Ruiyun Li, Zhiben Jiang & Bing Xu)

Additionally, the phylogeographic analyses confirmed the role of migratory wild birds in the circulation of H7N3 strains from North America into Mexico in 2012–2013.

Equally, same method have been used to reveal the HPAI H5N1 transportation by different bird species across Asia [11] and that the spread of HPAI H9N2 strains in Asia was a mixture of long-range distribution by wild birds attached with more restricted spread via the domestic bird trade.

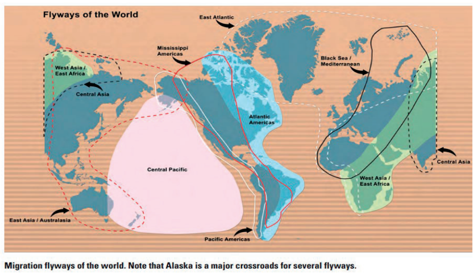


Figure 6. Flyways of migratory water fowl. Flyways run approximately north–south, and also overlap in northern regions, including in Siberia, Greenland, Alaska and across the Bering straits, which allows occasional transmission of influenza viruses between North America and Eurasia.
Flyways from http://wpe.wetlands.orgIwhatfly

In case of AI, the virus can be transmitted from bird to bird in birds the AI virus is shedded by feace and/or through contaminated material and usually the problems start when the domestic production systems are coming in close contact with wild birds [12].

The **poultry production system** and the trade of poultry, hatching eggs, one day chicks, etc are associated with risks [5, 16].

In general all countries in the world have developed measures to regulate risks production, risk trade [5, 6, 16], such as: legislation, bio security guidelines, financial incentives, compensations schemes etc however from documented evidence and current epidemiological data (audit reports [7], scientific studies) it is clear that there are not enough (Table 1).

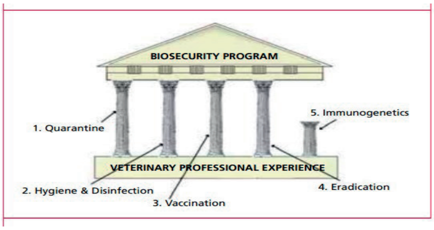


Figure 7. Biosecurity and supporting strategies for disease control and prevention (T. J. Bagust)

Different systems are exposed to different risks and every poultry farm have its own risk profile [5, 7, 16, Table 1] and capacity to spread the virus to the next farm, therefore measures and strategies developed and applied by the operators should be tailored to each farm (system), after a risk management is completed, in order to address their proper risks, otherwise it won't work. In other words, one size doesn't fit all and this feature must be seriously taken in consideration by each farmer, competent authority, government etc respectively each participant to the poultry production/trade system.

Table 1. Poultry system in five South east Asian countries affected by HPAI in 2003-2005

Country	Industrial	Large commercial	Small commercial	**Backyards**
Cambodia		<1%	<1%	**99,9%**
Indonezia	3,5 export and consumption	21,2	11,8	**63.4**
Lao		small	10	**90**
Thailand	70 % production export	10 % production	**10% production, 98% producers**	
Vietnam	small	20-25% production. Few producers	10-15% production, few producers	**65 % production**

Based on the data in the table and based on the impact of AI in these countries is very clear that the production system and the bio security measure have a critical role in the control of the waves of AI.

The world's **poultry population and the trade** have been rapidly grown in the last decades (Figure 8), driven both by demand and supply, according to FAOSTAT data, generating huge density of poultry populations and frequent movements.

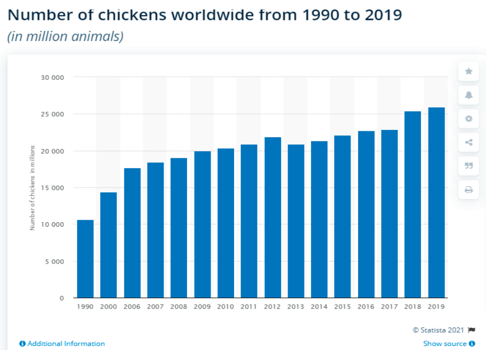


Figure 8. Number of chickens worldwide from 1990-2019

Statistics data shows that United States (18.262 MT) and Brazil (12910 MT), respectively the largest producers of poultry in the world, were/are rarely affected by AI. In contrast, the Republic of China (12300 MT) and the EU-27 (11560 MT) which are smaller producers then USA and Brazil, were/are frequently affected by the AI.

Analysing data related to biggest exporters of poultry in Brasil (3889 MT) and USA (3014 the AI is rare. On the other hand in EU-27 (1276 MT) and in Thailand (690 MT), both being big smaller exporters compared with Brasil and USA, both are frequently affected by the AI (Thailand was affected before 2004, then after they reviewed the production system, no new cases were reported).

Therefore we can conclude only for the cases described above that the size of production /trade can be factors that can trigger AI waves (EU-27, China, Thailand etc) in certain circumstances. The data are not comparable because many factors influence the final result

Particularly, documented evidences shows that Thailand before 2004 [6, 16, 15, 17, 19] was among the world major poultry exporters which produced almost 1 billion chickens per year. The production at that time was formed from commercial farms (some 9000 farms) but also from backyards (around 2.6 million BY) where poultry were raised for food in all the villages. On the other hand Thailand is one of the nine major migratory water birds flyways in the world and home of 50 millions migratory water birds (the flyway include 22 countries such as Russia, China, South East Asia [11], New Zealand and Australia).

Thailand experienced in 2004 [16] an outbreak of H5N1 avian influenza in poultry and in humans. More than 62 million birds died or culled and out of 17 human cases, 12 died. The epidemiological investigation revealed that most people were infected via direct contact with ill or deceased poultry, or when living in households with abnormal poultry deaths. The Government endorsed a three year plan. However, even epidemiologically speaking Thailand seems to be one of the countries regularly affected by HPAI, Thailand has not notified any HPAI since 2009.

Thailand suffered the greatest impact of the disease in 2004 (75% reduction in exports) followed by China, (63% reduction,) Hong Kong (55%) and 27% in the USA, whereas Brazil was the only country that increased (6%) exports (Taha, 2007) [2].

In USA in 2007, more than 190,000 wild birds were tested for AI and have not been detected in wild birds anywhere in North America even potential pathways (Figure 9) of avian influenza introduction from Asia [11] to North America is very clear exist.

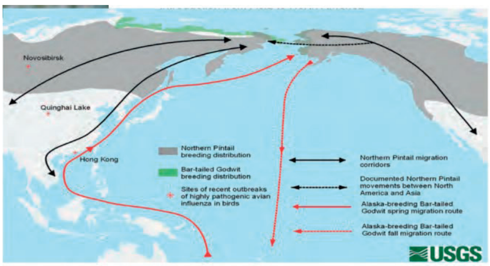


Figure 9. potential pathways of avian influenza introduction from Asia to North America

Outbreaks in domestic poultry caused by AI in USA, occurred, from time to time. For example, HPAI H5 viruses (H5N1, H5N2 and H5N8) were identified in 21 U.S. states from 2014 to 2015. According to CDC data in the past, there have only been a small number (fewer than 10 in 15 years) of reported human infections with North American avian influenza A H7 viruses. Most were associated with poultry exposure and have resulted in mild respiratory illness and/or conjunctivitis.

Some studies emphasise there is insufficient knowledge about the relation of avian influenza virus (AIV) to migratory birds in South America. According to some articles no occurrence of HPAI was reported in domestic or wild birds in Brazil. However, a few studies published data on LPAIV in Brazilian native fauna and exotic resident avian species. It seems that AI is considered an exotic disease in Brazil.

In 2011, in poultry, the United Nations Food and Agriculture Organization [9] considered six **countries to be endemic for HPAI H5N1 virus**:

- → Bangladesh,
- → China,
- → Egypt,
- → India,
- → Indonesia,
- → Vietnam.

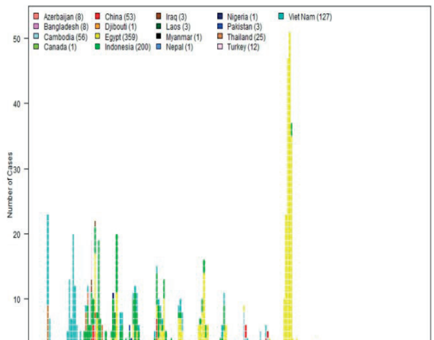


Figure 10. Epidemiological curve of AI (H5N1) cases in humans 2003-2020 (source, WHO)

In 2011, a FAO report concludes that countries listed above become endemically infected because they had **high proportion of poultry reared in very large 'backyard'**, which were sold under conditions of very poor bio security. According to them the poultry production in place plays a critical role in the maintenance and spread of H5N1 HPAI [20], backyard poultry being part of the cycle of infection, especially when the sale and movement of backyard poultry was done through long and complex market chains in conditions of poor bio security, with unreported outbreaks.

It seems that, measures have been developed everywhere in the world and that are similar covering prophylactic, and control and measures (minimum requirements) and they are also applied almost the same into entire world, even there are huge differences between the poultry production systems in countries (respectively huge technological differences between high income counties vs low income countries) and also in the same country (commercial farms vs family mixed own flocks, sustaining livelihoods) and environmentally. These observations are also backup by the data monitored by FAO who highlight in different reports how in developing countries small producers hardly ever take bio security measures or vaccinate their birds because they are familiar to lose part of flocks because of diseases. It seems that these kinds of farms are the most plausible mechanism to spread the virus between places which are not connected by the flyways of the migratory birds.

CONCLUSIONS

Today even all stakeholders (government, legislators, researchers, industry, public etc.) acknowledge the globalization, the emergence of transboundary diseases (e.g., zoonotic influence, emerging Coronaviruses - MERS, SARS, Covid etc) the threat related to the increase of worldwide recognized diseases (e.g., ASF, Salmonella, West Nile Virus, Bluetongue, AMR etc) and despite the huge amount of studies carried out we have also to admit that new scientific gaps have been identified and need to be addressed through further research and surveillance using new technologies. Biology is not simple, is not easily predictable (especially when we are referring to mutation, gene flow, genetic drift, or natural selection).In this context there is a need of good epidemiologists and scientists from different sciences. Is it critical, that in order to identify ways to manage better the AI pandemics we have to read firstly *the gaps in scientific information* (*ecology of influenza viruses, the adaptability of the virus to new host species, drivers of virulence, transmission mechanism etc)*.

As we saw from the review that are too many factors to manage and most of the time the data for different countries cannot be compared. Therefore, the future is the One Health approach. Countries must work together as partners and create a global network that can be used as a big management tool in building the strengths of the already existing programs and to broaden the beneficial effects of the critical capacity-building efforts, to promote epidemiological research in order to share methodology and scientific experience worldwide and to encourage all the stakeholders to work together (government – legislators – farmers – industry – mass media- people).

Another lesson learned from crises is that one size doesn't fit all and the profile risk of each farm, each country must be seriously taken in consideration by each farmer, competent authority, government etc respectively each participant to the poultry production / trade system. The poultry production in place plays a critical role in the maintenance and spread of H5N1 HPAI [14] , backyard poultry being part of the cycle of infection, especially when the sale and movement of backyard poultry is done through long and complex market chains in conditions of poor bio security, with unreported outbreaks.

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