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A self-assessment tool to improve poultry farm biosecurity regarding avian influenza

Ein Online-Tool zur Selbsteinschätzung der Biosicherheit in Geflügelhaltungen bezüglich aviärer Influenza

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Summary

Highly pathogenic avian influenza (HPAI) poses an important threat to poultry farming and the whole value chain. Since biosecurity is a major strategy to reduce the risk of HPAI virus introduction into farms and poultry flocks, a self-assessment tool for farmers concerning their farm-specific biosecurity management was developed. It is based on a questionnaire referring to risk factors retrieved from the literature or elaborated by experts, respectively. The risk factors are related to farm-, biosecurity- and animal health-management. Their epidemiological relevance is expressed through weights that were determined by an expert panel in a two-stage Delphi approach. The overall risk of a farm is estimated as the complementary to the percentage compliance with the measures assuring a maximum biosecurity as represented by the compiled questions and their respective weights.
The tool is offered as a free of charge, open-access web - based tool, the so-called AI-Risikoampel (AI-Risk Traffic Light), an online anonymous risk-check, which does not only allow to elicit farm-specific optimization potentials concerning biosecurity, but also generates a farm-specific to-do list with tasks ranked according to relevance. Biosecurity gaps may thus be closed by the farmer, possibly also in cooperation with a veterinarian or consultant.
The to-date experience concerning the acceptance of the tool and the user statistics are presented.

Keywords: HPAI, risk assessment, online-tool, poultry, Delphi method, biosecurity

Zusammenfassung

Die hochpathogene aviäre Influenza (HPAI) stellt eine erhebliche Gefahr für die Geflügelwirtschaft und ihre vor- und nachgelagerten Wirtschaftsbereiche dar. Da Biosicherheitsmaßnahmen von zentraler Bedeutung für eine Reduktion des Eintragsrisikos von HPAI-Virus in Geflügelbetriebe sind, wurde ein Instrument zur Selbstbewertung bezüglich des Biosicherheitsmanagements für Geflügelhalter entwickelt. Es fußt auf einem Fragenkatalog, der sich auf von Experten entwickelte und aus der Literatur zusammengetragene Risikofaktoren aus den Bereichen Betriebs-, Biosicherheits- und Tiergesundheitsmanagement stützt. Die epidemiologische Bedeutung der einzelnen Faktoren wird dabei über spezifische Gewichtungen abgebildet, die über eine zweistufige Delphi-Befragung einer Expertengruppe ermittelt wurden. Das Gesamtrisiko eines Betriebes wird als Komplementär zum Grad der Erfüllung der Anforderungen abgeschätzt, welche eine maximierte Biosicherheit gewährleisten, die durch die zusammengestellten Fragen und deren Gewichtungen repräsentiert wird.
Das Tool wird als kostenfreie und offene, web-basierte AI-Risikoampel angeboten, deren Nutzer anonym bleibt. Die Online-Risikoabschätzung ermöglicht nicht nur, Optimierungsmöglichkeiten hinsichtlich der Biosicherheit herauszuarbeiten, sondern auch eine betriebsspezifische To-do-Liste mit nach Priorität geordneten Aufgaben zu generieren. Auf Grundlage dieser Liste kann der Geflügelhalter, eventuell auch in Zusammenarbeit mit dem Hoftierarzt oder Beratern, Biosicherheitslücken schließen.
Die bisherigen Erfahrungen zur Akzeptanz und Nutzung des Tools werden vorgestellt.

Schlüsselwörter: HPAI, Risikobewertung, Online-Tool, Geflügel, Delphi-Methode, Biosicherheit

Introduction

The 2016/2017 epidemic of Highly Pathogenic Avian Influenza (HPAI) in Europe caused by the subtype H5N8 clade 2.3.4.4 group B (H5N8B) particularly emphasized its threat to poultry farming. Between November 2016 and November 2017, 107 outbreaks in captive birds (92 poultry holdings and 15 zoos/animal parks) and more than 1,150 cases of H5N8B in wild birds were reported in Germany (Fig. 1). In a number of cases, substantial gaps in farm biosecurity may have eased virus entry into the holdings. Furthermore, the introduction of the highly virulent virus into an area of high poultry density led to substantial farm-to-farm spread (Globig et al. 2017), which might have been avoidable, if biosecurity measures had been applied more strictly. Stamping out is the only measure to control HPAI outbreaks in poultry. In the case of the extraordinarily large epidemic (2016/2017), a two-digit million euro sum associated with the culling of approximately 1.2 million heads of poultry in addition to the costs due to economic consequences impacted the German poultry industry. In the subsequent years (2017-2018) the low level but constant virus circulation of H5N8B resulted in a reassortment with other European low pathogenic viruses and caused sporadic outbreaks.

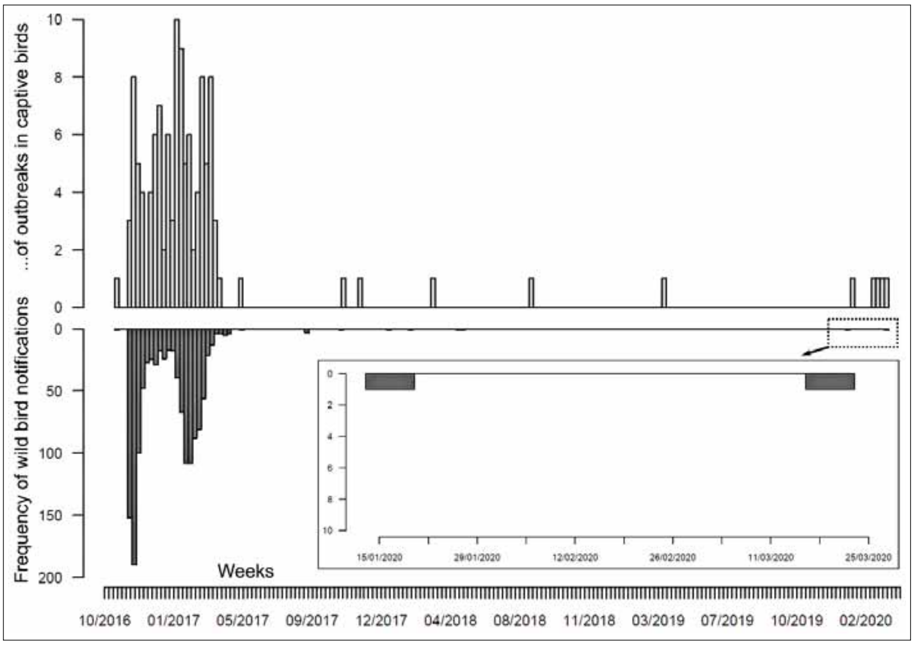

FIGURE 1: *HPAI notifications in wild birds and captive birds since October 2016 in Germany (Graphic: Institute of Epidemiology, Friedrich-Loeffler-Institut)*

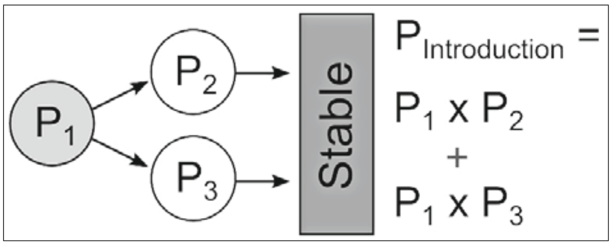

FIGURE 2: *Basic principles of risk pathways (Graphic: Institute of Epidemiology, Friedrich-Loeffler-Institut)*

Although Germany has been spared by larger epidemics since then, a novel reassortant of clade 2.3.4.4B H5N8 was newly introduced to Europe in December 2019 which caused several hundred outbreaks in domestic birds in Poland, Hungary, Bulgaria, Romania, the Czech Republic, Slovakia, Ukraine and Germany until May 2020. In Germany, besides two cases in wild birds, two large poultry farms and two non-commercial small holdings as well as a zoo were affected (Fig. 1). This clearly demonstrates the constant risk of disease introduction due to (i) continuous low level virus circulation and (ii) the risk of introduction of new HPAI viruses via migratory birds or trade. Thus, poultry farms are constantly at risk of experiencing HPAI outbreaks. Veterinary authorities and compensation funds ('Tierseuchenkassen') demanded that losses should only be compensated according to the level of biosecurity established and enforced on the affected holdings, at least during high-risk periods and in high-risk locations. This means, that compensation rates may be reduced according to the magnitude of serious gaps in biosecurity identified for example in the course of epidemiological outbreak investigations. Therefore, it is of utmost importance for poultry farmers to be aware of the potential pathways of virus introduction into holdings and the mechanisms of transmission to identify and apply farm-specific measures and thus to protect their poultry flocks.

As a consequence of the 2016/2017 epidemic, we developed an online tool, which allows poultry farmers to carry out a self-assessment of the quality of their individual farm biosecurity. The tool is based on a questionnaire with questions relating to risk factors of HPAIV introduction. The questions and answers were compiled and weighted (in a two-stage Delphi process) by experts.

Delphi studies are a widely used method to obtain input from groups of experts (Chia-Chien and Brian 2007). Initially developed to predict cold war enemy attack probabilities, the technique has been used across numerous disciplines as a method to elicit expert opinion in an iterative and structured manner (Diamond et al. 2014). The key features of the method are anonymity among the participants of the Delphi process in conjunction with controlled summarized feedback of the group opinion. The participants may adjust their initial ratings based on the feedback in a number of subsequent iterations (Chia-Chien and Brian 2007). Anonymity reduces socio-psychological effects, which might bias opinion making in groups (Vorgrimler and Wübben 2003). Classically, the method seeks to elicit consensus on the topic under study, though there are variations of the Delphi such as the dissensus or Policy Delphi that aim to seek a broad range of opinions without achieving consensus (Steinert 2009).

The "AI risk traffic light" ("AI-Risikoampel") is implemented as a questionnaire-based web application and offered free of charge (https://risikoampel.uni-vechta.de/). It does not only allow to elicit farm-specific deficiencies in biosecurity, but also generates a farm-specific to-do list with the tasks ranked according to their importance. Referring to this list, deficiencies may be

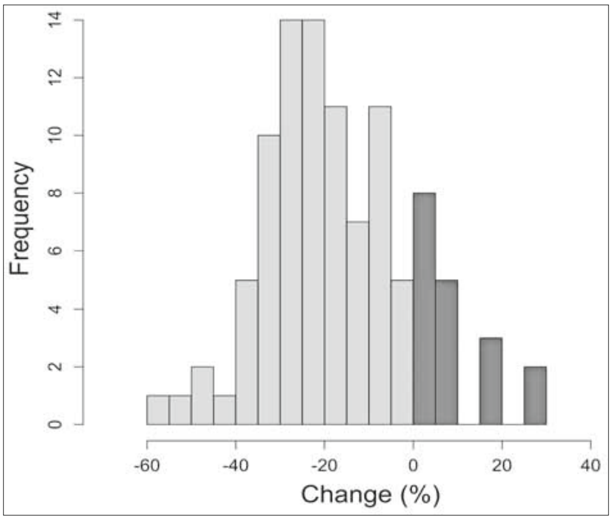

FIGURE 3: *Change in correlation coefficient 2nd Delphi versus 1st Delphi – individual questions*
(Graphic: Institute of Epidemiology, Friedrich-Loeffler-Institut)

eliminated by the farmer, possibly also in cooperation with a veterinarian or a consultant.

Material and Methods

Design of the questionnaire

The questions asked in the online questionnaire were formulated in German on the basis of the relevant national legislation for AI disease control (Geflügelpest-Verordnung) and expert consultation (see below). The questions relate to potential sources of HPAIV introduction into a farm and its stables and were grouped into six categories: (i) farm/premises, (ii) farm organization, (iii) unclean sector, (iv) interface unclean – clean sector, (v) operational management, and (vi) cleansing/disinfection/rodent control. Expert opinion elicited in a Delphi study was used to allocate a weight of importance for each question and for the overarching categories in a two-stage approach modified from Geenen et al. (2008), Wilke et al. (2011) and Gelaude et al. (2014). The category weights served as an additional multiplier for the individual weights of the questions in the respective category. The rationale behind this approach was based on two arguments:

The risk of HPAI introduction may be described by risk pathways, in which some risk sources act in an additive, but others in a multiplicative fashion (Fig. 2). Any step in a multiplicative segment of a pathway, for which the risk may be reduced to almost zero, would markedly affect the overall impact of the pathway irrespective of the risk status of any preceding or following step. For instance, the integrity of the interface between the unclean and the clean sector of the farm (P_2 in Fig. 2) can prevent disease introduction regardless of the farm location, i.e. near breeding grounds of potentially infected wild birds (P_1 in Fig. 2). Allocating an additional weight to the above mentioned categories, i.e. to the interface of the unclean to the clean sector, may allow to account for this effect, regardless of the number and weight of questions in the respective category.

Secondly, the number of questions and their degree of detail concerning different aspects of biosecurity markedly influence the valuation of the aspect under consideration. For instance, one may ask for the presence of soap, disinfectant and towels in the hygiene lock in three separate questions or in a single one with an enumeration of the items. As all these features are important for the function of the lock, assessing their presence separately for each item can increase the relative importance of the lock. This problem may also be controlled by allocating an additional weight at the overarching level, i.e. the category, the questions belong to.

Identification of questions and answer options

Based on a literature research, relevant risk factors for HPAIV introduction into poultry farms were identified. Major sources of information were the biosecurity measures laid down in the German Decree on Avian Influenza Control (Geflügelpest-Verordnung) and checklists (Checkliste FLI 2017; Checkliste ZDG 2017) conceptualised and jointly published by the Friedrich-Loeffler-Institut (FLI) and the German poultry association (Zentralverband der deutschen Geflügelwirtschaft e.V., ZDG). The identified risk factors were then addressed by questions. Two to three pre-defined answers were attributed to each question accordingly. This led to a multiple-choice system of questions and answers, which helped to obtain comparable results from all participating farms. The predefined answers were coded according to the level of compliance with the respective biosecurity aspect they related to. The first answer refers to complete compliance with the possible biosecurity measures (coded as 1) with respect to the specific risk factor (question), the second answers refers to the absence of the respective measures (coded as 0). For some questions, an additional intermediate level of compliance (coded as 0.5) was provided as a possible answer. If relevant, the answer "not applicable" (to the assessed farm) was also added as an option (e.g. cleansing and disinfection of the feed storage. If there was no grain store on the farm, "not applicable" could be selected). Answers were regarded as mutually exclusive, i.e. only one option could be marked. Questions specified as "not applicable" were excluded from the calculation of the risk estimate (see below).

Risk factors, questions and the respective answer options were reviewed by an expert panel of 17 experts from veterinary authorities (4), veterinary research institutions (4), veterinary practice (3), poultry and egg producers (3) as well as regional product boards for poultry and eggs (3) with respect to comprehensiveness, intelligibility and plausibility.

Determination of weights of importance by the Delphi method

The expert panel was asked to participate in a two–stage Delphi study to derive specific weights for each risk factor for HPAIV introduction. The objective was to reach consensus among the experts and the degree of consolidation of expert opinion was assessed (see below). The experts received a compilation of the questions and answers (supplementary material) used in the questionnaire by e-mail. They were asked to allocate 100 points of risk to the six categories of questions and a weight score of 1, 2 or 3 to each question. In a second step, they were motivated to reconsider the questions, to which they had allocated a weight of 3, and asked to replace this value by a weight of 5, if they believed that the risk factor behind the question had extraordinary importance. The weights

TABLE 1: *Change in correlation coefficient 2nd Delphi versus 1st Delphi-categories*

Category	Change in cv* (%)
I	–20.1
II	–28.7
III	+5.4
IV	–26.7
V	–9.7
VI	+42.6

* coefficient of variation

assigned by the experts in this first poll (1st Delphi round) were analysed and minimum, maximum, mean and median calculated. These measures were communicated to the experts, who were then asked to re-evaluate their estimates (2nd Delphi round).

Assessment of the consolidation effect of the Delphi-method

To assess the impact of the 2nd Delphi round on the spread of scores assigned to the different categories and individual risk factors, correlation coefficients (Petrie and Watson 2006) were calculated for the results of the 1st and 2nd Delphi round, respectively, and the differences expressed as percentages of change.

Calculation of the risk estimate and presentation in the online-tool

The maximum achievable biosecurity score was calculated as the sum of the products answer code x risk factor (question) weight x category weight for all applicable questions. The biosecurity level of the farm was then expressed as the percentage of the achieved score relative to the maximum score. In addition, it was displayed using a traffic light color code: <33%, high risk, red; 33–66%, intermediate risk, yellow; >66%, low risk, green. A to-do list with recommendations for improving biosecurity, ranked top-down according to the risk factor relevance (product as specified above) for the specific farm was also provided.

Programming, web presentation and privacy considerations

The online tool was programmed on a Stud.IP platform. The "Online course support for classroom teaching" (Stud.IP) is an internet-based, open-source platform to support teaching and research (Stockmann and Berg 2005). Stud.IP has a modular structure and may be expanded and upgraded via standardized extensions, so-called plugins.

The use of the online tool is anonymous, i.e. an assignment of the operating results via an IP or other data is not possible during or after use. For an evaluation on a regional basis, five assignment parameters, i.e. country, number of stables, total number of animals, poultry type and the background of use (primary/secondary professional use; academic interest, only) are queried.

The data themselves are stored on a server at the IT centre of the University of Vechta and may only be used for an evaluation after consultation with the project team.

Participation is without any (particularly without official) consequences for the user. The online tool only serves as an aid for an evaluation of individual farms under the responsibility of the farmers themselves. The user is provided with the option to download (as a PDF document), print or save the generated recommendations for biosecurity optimisation and the to-do (check-) list. Access to and use of the online tool are free of charge.

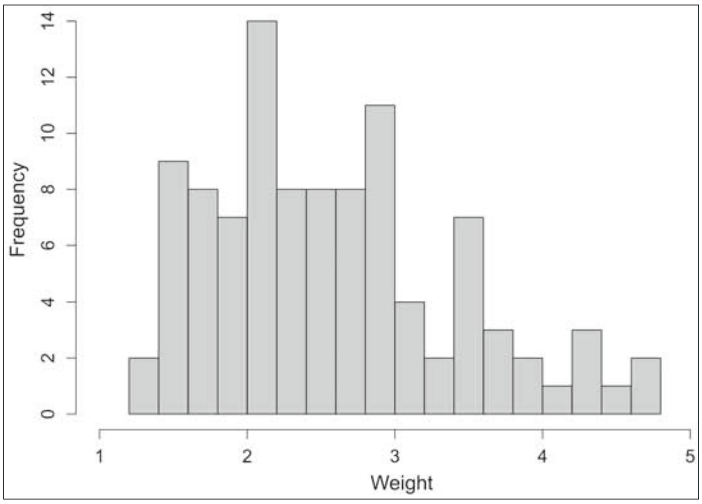

FIGURE 4: *Distribution of weights assigned to individual questions (mean after 2nd Delphi) (Graphic: Institute of Epidemiology, Friedrich-Loeffler-Institut)*

Results

Questionnaire

In total, the experts selected 100 questions (including the respective answer options) related to potential risk factors of HPAIV introduction, which were grouped in categories as follows: farm, premises (17 questions), farm organization (19), unclean sector (17), interface unclean/clean sector (20), operational management (18), cleansing/disinfection/rodent control (9).

Weight of categories and questions

The response rate in the first and second Delphi round was 100% each, i.e. all experts completed their tasks in both Delphi rounds. Concerning the weights of the categories, the average reduction in variation among the expert panel opinions was –6.2% between the 1st and the 2nd Delphi round. The changes for the individual categories are listed in table 1. For categories III and VI, the agreement among the experts had deteriorated in the 2nd Delphi round as compared to the first one. As regards the individual questions, the average reduction in variation was –16.9%. Of the 100 questions, only 18 deteriorated in their variation between the first and second Delphi round (maximum 29.1%). A histogram of the changes from the 1st to the 2nd Delphi round is provided in figure 3.

The expert panel assigned the following weights (share of 100 points, rounded means after 2nd Delphi) to the categories: farm premises: 22.5, business organization: 15.9, unclean sector: 15.0, interface unclean – clean sector: 19.0, operational management: 16.2 and cleansing/disinfection/rodent control: 11.3.

Concerning the 100 individual questions, the minimum weight (mean after the 2nd Delphi round) assigned by the experts was 1.35, the maximum 4.65, the mean weight 2.58 and the median 2.53. The distribution of the weights is displayed in figure 4.

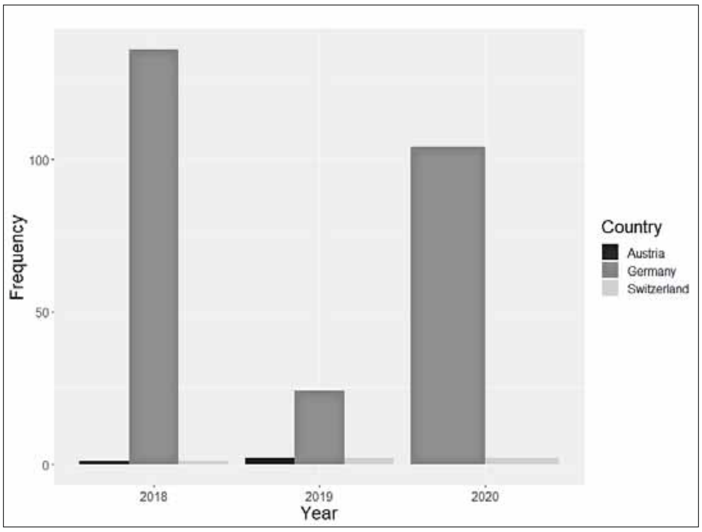

FIGURE 5: *Access frequency of the "AI Risikoampel" by year and country (as of March 31st 2020) (Graphic: Institute of Epidemiology, Friedrich-Loeffler-Institut)*

The two questions with the lowest weights (Fig. 4) related to the presence of a social room for the farm staff and the presence of birds of prey in the vicinity of the farm. The two questions with the highest weight scores referred to the sharing of machinery among different farms and the mandatary use of stable-specific footwear (shoes, boots or disposable boot covers).

Access statistics/acceptance of tool

Since its launch in June 2018 (Universität Vechta 2018) the tool was accessed 581 times until 31 March 2020, predominantly by German users (Fig. 5). It became evident that the access frequency dropped markedly after the year of the launch, but returned to a value above 100 within the first quarter only of 2020.

Discussion

The HPAI H5N8B epidemic 2016/2017, the worst ever recorded for Europe, drove the demand for a tool that allows farmers to assess the biosecurity status of their individual farms. The tool was implemented in a web-based fashion to foster acceptance among the poultry industry. The selection and grouping of the relevant risk factor-related questions and the respective answer options required intensive discussions, facilitated in a two-step Delphi process, and the willingness of the experts to find compromises. We believe that the most important aspects contributing to the risk of disease introduction into farms and poultry flocks are sufficiently represented in the questionnaire and in the implementation of the online tool. It is impossible, however, to present all the questions individually in the context of this publication, but they are freely available online (Risikoampel Universität Vechta: www.risikoampel.uni-vechta.de).

The Delphi method generally worked well in consolidating the weight ratings. The average effect considering the categories was small but noteworthy; the average effect on the weight variation of the individual questions was even larger.

When focusing on the changes of the coefficient of variation of the categories in the Delphi process (Tab. 1), it is striking that the last category of the list (VI) yielded the most marked and deteriorating change (+42.6%). This might be triggered through the specific design of the first level of weighting, in which the experts were asked to divide a total of 100 scoring points between the six categories. Perhaps some experts adapted their scores top-down in the light of the results of the 1st Delphi, ending up with category VI, to which then the remaining score adding up to 100 was allocated.

When the effect of the Delphi process on the individual questions was examined, it became evident that the opinion of a single expert could result in a marked deterioration of the variation in some cases. This can be illustrated by a detailed analysis of the opinions concerning question 69 (of 100), which showed the maximum deterioration in variation (+29.1%). This risk question dealt with the existence of a social room for employees, which the experts apparently considered only as a proxy only for other important biosecurity measure or as unimportant (lowest weight). The 1st Delphi round thus yielded a minimum score of 1, a maximum of 2, and mean and median of 1.5. In this specific situation, changes in opinion from 1 to 2 are theoretically as likely as vice versa, thus favoring preservation of the initial variation. However, a single expert increased his score from 2 to 3, which accounted for the large quantitative impact on the change in variation.

It has to be emphasized that the attempts made to cope with the fact that risk factors in a scenario tree or a risk pathway of disease introduction are often linked in a multiplicative rather than an additive fashion (Fig. 2) may require improvement. Feeding the information from an online questionnaire of self-assessment into an elaborated, expert-evaluated risk analysis model yielding on-the-fly results for the user might be an option for the future. Such a model could even be stochastic, but is demanding to implement as a web tool.

Nonetheless, the tool presented here is considered as sufficiently fit for purpose. It does not only allow poultry farmers to assess the biosecurity status of their farms regarding HPAI individually and still anonymously, the results of the analysis are also displayed like a traffic light for easy and coherent interpretation. In addition, the tool generates a "To-do List" with tasks and recommendations ranked according to importance for the individual farm. This list can be printed and used as a practical guide for improving farm biosafety and biosecurity. These features may explain the acceptance of the tool as demonstrated by the access statistics (Fig. 5). In conjunction with figure 1, these statistics also indicate that the access rate is obviously driven by the incidence of HPAI notifications/outbreaks.

The AI-Risikoampel already served as a model for further self-assessment tools targeting other diseases, in particular African Swine fever (ASF). In 2019, the ASF-Risikoampel was developed and made available to the public (https://risikoampel.uni-vechta.de/). Further applications for cattle and other animal species as well as the translation into other languages are planned.

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Conflict of interest

The authors declare that they have no conflicts of interest. The authors declare that they have no affiliations with or involvement in any organization or entity with any financial interest in the subject matter or materials discussed in this manuscript.

Ethical approval

No ethical vote was necessary. The authors declare that no research interventions or experiments with animals or human beings, no clinical trials as well as no clinical research were conducted in the context of this study.

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Authors contribution

AG: Project development, manuscript writing and editing, BG: Project idea development and evaluation, manuscript writing and editing. AW: Project development and evaluation, FJC: Project idea and development, manuscript editing. ND: Project development, data analysis, manuscript writing, manuscript editing. All authors corrected and approved the final version.

References

Checkliste FLI (2017): Vermeidung der Einschleppung der hochpathogenen aviären Influenza (Geflügelpest). https://www.openagrar.de/servlets/MCRFileNodeServlet/openagrar_derivate_00002067/Checkliste-Gefluegelpest-2017-03-17.pdf, last accessed May 5th, 2020.

Checkliste ZDG (2017): https://zdg-online.de/wp-content/uploads/2017/10/ZDG-Checkliste-Vogelgrippe.pdf, last accessed May 5th, 2020.

Chia-Chien H, Brian AS (2007): The Delphi Technique: Making Sense of Consensus. Practical Assessment. Res Eval 12: 1–8.

Diamond IR, Grant RC, Feldman BM, Pencharz PB, Ling SC, Moore AM, Wales PW (2014): Defining consensus: A systematic review recommends methodologic criteria for reporting of Delphi studies. J Clinical Epidemiol 67: 401–409.

Geenen P, Grabkowsky B, Saatkamp H, Windhorst HW (2008): Explorative study on avian influenza risk factors in the EU-27: literature study and Delphi-based expert opinion. In: Development of new integrated strategies for prevention, control, and monitoring of epizootic poultry diseases. Final report for the European Commission, Wageningen Niederlande, 2008.

Geflügelpest-Verordnung (2018): Geflügelpest-Verordnung in der Fassung der Bekanntmachung vom 15. Oktober 2018 (BGBl. I S. 1665, 2664).

Gelaude P, Schlepers M, Verlinden M, Laanen M, Dewulf J (2014): Biocheck.UGent: A quantitative tool to measure biosecurity at broiler farms and the relationship with technical performances and antimicrobial use. Poult Sci 93: 2740–2751.

Globig A, Staubach C, Sauter-Louis C, Dietze K, Homeier-Bachmann T, Probst C et al. (2017): Highly Pathogenic Avian Influenza H5N8 Clade 2.3.4.4b in Germany in 2016/2017. Front Vet Sci 4: 240. DOI: 10.3389/fvets.2017.00240. #bitte statt et al. alle Autoren hier auflisten#

Grabkowsky B (2009): Qualitative GIS-based risk assessment of Avian Influenza introduction in the EU-27. In: Turkey Production: Towards better Welfare and Health, Berlin, 292–305.#im Text nicht verwiesen; bitte nachholen oder hier streichen#

Petrie A, Watson P (2006): Statistics for Veterinary and Animal Science. 2nd ed. Blackwell Publishing, Oxford, UK.

Risikoampel Universität Vechta: https://risikoampel.uni-vechta.de/, last accessed May 5th, 2020.

Steinert M (2009): A dissensus based online Delphi approach: An explorative research tool. Technol Forecast Soc Change 76: 291–300.

Stockmann R, Berg A (2005): „Stud.IP" – Ein Informations- und Managementsystem zur Unterstützung von Lehre und Forschung. eleed e-learning & education.

Universität Vechta (2018): Geflügelpest-Risikoampel: Neues Online-Tool zur Seuchenprävention. https://www.uni-vechta.de/news-einzelansicht/news/detail/News/gefluegelpest-risikoampel-neues-online-tool-zur-seuchenpraevention/, last accessed May 5th, 2020.

Vorgrimler D, Wübben D (2003): Die Delphi-Methode und ihre Eignung als Prognoseinstrument. Statistisches Bundesamt, Wi Sta 8: 763–774.

Wilke A, Windhorst H-W, Grabkowsky B (2011): Analysis of risk factors for the introduction of Salmonella spp. and Campylobacter spp. in poultry farms using Delphi method. Worlds Poult Sci J 67: 615–630.

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