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Effectiveness and importance of on-farm biosecurity measures in Switzerland

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Summary (English)

In livestock sciences, the term biosecurity is used to describe all measures implemented to protect animals from infectious diseases. In addition to official actions (e.g. mandatory vaccination, import restrictions), numerous on-farm biosecurity measures also contribute to safeguarding livestock health. The aim of this study was to evaluate the degree of protection attributed to individual on-farm biosecurity measures. Therefore, an elicitation of sixteen Swiss animal disease experts was conducted. The importance and the effectiveness of individual on-farm biosecurity measures applicable to cattle or swine farms were assessed using a modified Delphi method. The elicitation process consisted of one-on-one interviews, during which card-sorting was applied to rank 32 individual biosecurity measures, succeeded by a written report, oral discussion and reevaluation of the results.

For cattle farms, measures on disease awareness were ranked as being of utmost importance, whereas those on preventing contact to the outside world were given the lowest importance. For swine farms, measures on animal movements were rated as being the most important, those related to feedstuff as the least important. Among all measures evaluated, education of farmers was considered to be the most efficient (i.e. important and effective) in keeping Swiss livestock free from disease.

The results were tested for correlation using Spearman's rank correlation coefficient (r_s) as well as for agreement between experts using Intraclass Correlation Coefficient (ICC). Based on the experts knowledge gathered, a database was created that can be used to generate recommendations for farmers and policy makers. The semi-quantitative data obtained substantially contribute to creating a platform for a scientific discussion on biosecurity.

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Zusammenfassung (Deutsch)

Der Begriff Biosicherheit umfasst sämtliche Massnahmen, welche dazu beitragen, die Nutztierpopulation vor Infektionskrankheiten zu schützen. Nebst staatlichen (z.B. Impfobligatorium, Importbeschränkungen), tragen auch zahlreiche betriebliche Biosicherheitsmassnahmen zu einem vorteilhaften Gesundheitszustand der Nutztiere bei. Das Ziel dieser Arbeit war, die Schutzfunktion der einzelnen Massnahmen zu quantifizieren. Dazu wurden mittels einer modifizierten Delphi Methode jeweils acht Schweizer Rinder- respektive Schweineexperten zu Wichtigkeit und Wirksamkeit individueller Biosicherheitsmassnahmen befragt. Die Befragung setzte sich aus drei Stufen zusammen: Einzelinterviews, welche eine Rangierung von 32 Biosicherheitsmassnahmen auf Kärtchen beinhaltete, Feedback durch einen Expertenbericht, welcher die eigenen Antworten und einen Expertenmedian darstellte, und ein Gespräch, mit der Möglichkeit allenfalls Änderungen an den eigenen Antworten vorzunehmen.

Massnahmen bezüglich disease awareness/Früherkennung wurden als am wichtigsten, diejenigen bezüglich Kontakt zur Aussenwelt als am wenigsten wichtig für Rinderbetriebe, beurteilt. Für Schweinebetriebe wurden Massnahmen bezüglich Tierverkehr als am wichtigsten, solche bezüglich Futtermittel als am wenigsten wichtig beurteilt. „*Ausbildung der Tierhalter*“ wurde von allen Massnahmen als die effektivste (Kombination Wichtigkeit und Wirksamkeit) angesehen, um den Schweizer Nutztierbestand vor Infektionskrankheiten zu schützen.

Die Resultate wurden bezüglich Korrelation und Übereinstimmung zwischen den Experten getestet, durch Berechnung des Spearman’s rank correlation coefficient (r_s) respektive des Intraclass Correlation Coefficient (ICC). Eine Datenbank wurde erstellt, welche erlaubt, Empfehlungen zur Umsetzung von Biosicherheitsmassnahmen zu erstellen. Die gewonnenen semi-quantitativen Resultate leisten somit einen wertvollen Beitrag zu einer wissenschaftlichen Diskussion der Thematik Biosicherheit.

Expert elicitation on the effectiveness and importance of on-farm biosecurity measures in Switzerland

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Abstract

Biosecurity measures are an important element of safeguarding livestock from infectious diseases. Although several sources provide recommendations, scientific evidence on the effectiveness of individual biosecurity measures is scarce and difficult to obtain. Therefore, the objective of this study was to assess the effectiveness and the importance of individual (31 for cattle or 30 for swine) on-farm biosecurity measures in Switzerland, through expert elicitation. Using a modified Delphi method, sixteen Swiss animal disease specialists were questioned. The assessment of the importance was based on the current situation in Switzerland, by considering feasibility, effort and benefit of each measure, as well as Swiss legislation. The effectiveness of measures in preventing a particular infectious agent from entering and spreading was specifically evaluated for individual pathogens, by taking into consideration only their transmission characteristics. The model pathogens assessed by cattle experts were those causing Bluetongue (BT), Bovine viral diarrhea (BVD), Foot and mouth disease (FMD) and Infectious bovine rhinotracheitis (IBR), whereas swine experts assessed those causing African swine fever (ASF), Enzootic pneumonia (EP), Porcine reproductive and respiratory syndrome (PRRS) and as well FMD. For cattle farms, measures on disease awareness were ranked as most important, those on preventing contact to the outside world as least important. For swine farms, the measures on animal movement were rated as the most, whereas those related to feedstuff as the least important. Among all measures evaluated, education of farmers was considered to be the most efficient (combined importance and effectiveness) to keep Swiss livestock free from disease. The results of the elicitation were tested for correlation between importance and effectiveness using Spearman's rank correlation coefficient (r_s), as well as for agreement between experts by means of Intraclass Correlation Coefficient (ICC). Based on the expert's knowledge a tool was designed to generate recommendations for the implementation of on-farm biosecurity measures.

Keywords: Expert consultation, Delphi, Animal diseases, Risk profile, Cattle, Swine

1. Introduction

Biosecurity is defined as management-practice activities that reduce the opportunities for infectious agents to gain access to, or spread within, a food animal production unit (Thrusfield, 2007). In Switzerland and in many other countries, biosecurity consists of a combination of national and voluntary on-farm measures. The significance of on-farm biosecurity was emphasized in the European Union animal health strategy 2007-2015 “Prevention is better than cure”. Within the first draft of the new Animal Health Law of the European Union, an attempt was made to focus on on-farm biosecurity in order to allow for free trade across the borders of different European countries (European Commission, 2007). This policy would commit farmers to safeguard high standards of biosecurity. However the Swiss approach to keeping the livestock population free from disease is increasingly moving towards governmental control measures, with the compulsory bluetongue (BT) vaccination in 2008 – 2010 (FVO, 2009) and the ongoing bovine virus diarrhea (BVD) eradication (Presi et al., 2011) being notable examples. Furthermore, Switzerland’s on-farm biosecurity measures are not well established. However, despite the global trend towards less and bigger enterprises, Swiss livestock herds are still small-sized. In 2011 the average herd size of a Swiss cattle farm was 39, and that of a Swiss swine farm 190 (2001: cattle 33, swine 105) (FSO, 2012). It is well documented that the overall infection risk in large-scale commercial holdings appears significantly higher as compared to small holder operations (Van Steenwinkel et al., 2011). On the other hand, larger enterprises seem to implement a stricter biosecurity management than small and backyard holdings (Hoe and Ruegg, 2006; Nöremark et al., 2010). With increasing production intensity a stronger emphasis is given to external biosecurity (prevention of disease introduction) but a weaker emphasis to biocontainment (prevention of further spread of disease) (Graham et al., 2008). Nevertheless, despite the poor implementation of on-farm biosecurity measures, Switzerland shows a favorable animal disease status (WAHID, 2012).

Several publications focusing on biosecurity have described the measures implemented along with factors influencing the implementation, such as the attitude of farmers (Casal et al., 2007; Cross et al., 2009; Schemann et al., 2012). Furthermore, numerous articles give advice as to which measures should be applied to keep disease risk at a minimum (Barceló and Marco, 1998; Snively, 2001; DEFRA, 2003; Moore et al., 2008). However, these recommendations usually derive from general knowledge on infectious diseases and only rarely rely on scientific evidence. Moore et al. (2008) reviewed recommendations on biosecurity practices from different sources and suggested that the variety of different recommendations published, might confuse and thus discourage farmers from implementing them. In addition, the absence of proven efficacies, combined with the lack of relevant education are potential reasons for infrequent or no compliance to biosecurity measures (Brennan and Christley, 2012). For communication to farmers, it would be essential to be able to describe the protective effect of different biosecurity measures. The evaluation of biosecurity could be achieved by monitoring the measures applied relative to disease occurrence over time. However, in the field, biosecurity is always the result of a combination of measures under different conditions (such as housing or environment), making an assessment of single measures almost impossible. On the other hand, testing biosecurity measures under controlled experimental settings can result in a challenge to extrapolate experimental data to field conditions. Approaches to objectify the effectiveness of biosecurity measures would be to calculate the reproductive rate of an infection (R0) for different scenarios (Lindberg and Houe, 2005) or to estimate the “population attributable fraction” (PAF) of disease for each measure as a risk factor. The latter is defined as the percentage of disease in the population that could be prevented through elimination of a risk factor (Wells, 2000). However, only few veterinary studies using one of these parameters have been conducted so far. This may be due to the fact that it is difficult to deal with the correlations of different measures among themselves and with external factors in field studies. In a situation where objective field data are unavailable and difficult to study, it is a common procedure to gather knowledge through expert elicitation (Fasina et al., 2012; Horst et al., 1998). The characteristics of infectious agents, routes of transmission and general farming practices are well documented and constitute the basis for the assessment of biosecurity measures. The aim of this study was to consolidate existing knowledge on the role of different on-farm biosecurity measures, using an expert elicitation. Based on the importance and the effectiveness of individual measures, a semi-quantitative ranking was established. The output forms a basis for recommendations to farmers as well as for policy-making towards risk based surveillance and control programs.

2. Materials and methods

2.1. Expert elicitation

A modified Delphi method inspired by Morgan et al. (2002) was applied. The expert elicitation consisted of one-on-one interviews, sending reports and one-on-one phone calls for the discussion and revision of the results.

2.1.1. Selection of experts

All experts were veterinarians with a long-time work experience with animal diseases in veterinary public services (n=6), universities (n=6) or animal health institutions (n=4) in Switzerland. These are the experts most likely to be consulted in the case of an infectious disease event. All cattle and swine experts contacted (eight for each species), agreed to participate in the elicitation. Each expert was questioned at a location of his choice and always by the same interviewer.

2.1.2. On-farm biosecurity measures

Based on literature, a list of on-farm biosecurity measures was created, which focuses on spreading characteristics of infectious agents. Since animals (livestock, wild animals, pets), people (farmers, workers, visitors), vehicles, equipment, water, feedstuff, bedding, manure and air can all be carriers of infectious agents, the measures were grouped into 10 corresponding categories (Tables 1 and 2). Finally, 32 on-farm biosecurity measures, of which 31 measures are applicable to cattle farms (Table 3) and 30 to swine farms (Table 4) respectively, were listed. "*Vaccination*" was listed as one measure belonging to the category "reduction of infection pressure" and evaluated for the individual diseases.

2.1.3. Pretesting of interviews

The set-up was designed based on the experience from the four pilot interviews. The original plan to design the scoring system based on transmission routes had to be dropped due to difficulties appearing in these pretests. On these grounds the basis was changed to the evaluation of specific diseases. These were chosen as being representative for diseases with vector-borne transmission (BT), (re)-emerging diseases (ASF), those having a high economic impact (FMD), and finally diseases that are particularly relevant for Switzerland. The latter are, either, officially eradicated and only appear sporadically (EP and IBR), do not occur despite being endemic in neighboring countries (PRRS) or are subject to an on-going eradication program (BVD).

2.1.4. Interviews and reports

Each biosecurity measure was written on a card, with some being accompanied by a brief explanation on the back side of the card (e.g. "farmer observes and knows its animals; he keeps records of disease occurrence and treatments" as explanation for "*Animal health monitoring by the farmer*"), in order to ensure that all experts understand the same definition. The cards were shuffled and handed over to the experts for rating. The experts were given the possibility to write down and evaluate additional biosecurity measures if they thought the list was incomplete, inapplicable or not precise enough.

The first task was to sort the cards based on the importance of each measure in preventing an infectious agent from entering and spreading. The decision should consider feasibility, effort and benefit of the measure, as well as Swiss legislation. The second task was to judge the effectiveness of the measures in preventing a particular infectious agent from entering and spreading. This time, effort and feasibility of the measure as well as the prevalence of the disease should not play a role for the decision. Cattle experts judged the effectiveness for the pathogens causing BT, BVD, IBR and FMD, swine experts for those causing ASF, EP, FMD and PRRS. The diseases were rated by the experts in a random order.

The cards had initially to be sorted along an arrow, from no to utmost importance. Only in a second step, the expert was presented a scale from 0-5 and asked to allocate a number to the cards. This intended to assist the expert in focusing on the task at first and then prompt him to elaborate a semi-quantitative assessment. For the assessment of the effectiveness, it was left open to the expert to choose whether he prefers to use the scale from 0-5 in a first or in a second step like in the assessment of the importance.

The possibility to ask questions was given at any time. A declaration of agreement containing a written explanation of the task was handed over to each expert for signing. The interviews were audiotaped for the purpose of documentation. At the end of each interview, the experts were asked to assess their own knowledge on the four diseases, using a score from 1 to 6, with 1 being the poorest and 6 the best.

Following the completion of all 16 interviews, a report was sent to each expert, consisting of five bar charts showing his answer and the median of the answers of all experts for the respective species. Also presented were the minimum and the maximum of the answers for each measure. Each expert was given the possibility to revise his answers during a phone call. Changes were documented and the revised values were used to establish the database.

2.2. External revision

The revised results (median and range values) for the effectiveness of the measures were presented to international experts, two for each species. They were chosen based on suggestions from Swiss experts, taking into consideration their involvement in disease control in different countries within the European Union and their recognition as experts either in cattle or swine diseases. They were asked to express their degree of agreement or disagreement on the assessment by the Swiss experts. The results for the importance were not revised externally as they were specifically evaluated for conditions in Switzerland.

2.3. Statistical methods and database

The results of the expert elicitation were described by the median, quartiles, and the range of the scores given by the swine and cattle experts. Correlation between the assessment of importance and effectiveness of different biosecurity measures was described by the Spearman's rank correlation coefficient (r_s).

To assess agreement among the different experts, the absolute value of the difference between scores was calculated for each pair of experts and each biosecurity measure. Percent of total agreement (difference of 0), and deviation by different amounts (from 0.5 to 5) was used for the description of raw agreement among experts. The percentage of variance in scores which can be attributed to the influence of individual experts was assessed by calculating Intraclass Correlation Coefficients (ICC) from nonparametric repeated measures ANOVA models on ranks of scores. In these models, the outcomes were the scores on importance and effectiveness for the different diseases and animal species, respectively. For calculating ICC expert, the individual biosecurity measures were entered as subject variable, and the experts were entered as a random effect. The ICC for contribution of experts to the total variance of scores was calculated from the model output as described by Shrout and Fleiss (1979):

$$ICC = \frac{Mean\ Square\ (Expert) - Mean\ Square\ (Residual)}{Mean\ Square\ (Expert) + (k-1) Mean\ Square\ (Residual)}$$

Where (k-1) is the degrees of freedom for the model. ICC measure was calculated accordingly. Statistical analyses were performed with the software NCSS 8 (Hintze, 2012).

A database was established using Microsoft Access 2010. The median scores of all experts were entered for each biosecurity measure. Multiplying the median effectiveness and the median importance leads to a combined score for each biosecurity measure, disease and animal species. The results from the Swiss experts are presented in Table 3 and Table 4 separately for each species. The median, which was used for calculations, and the range of the answers given by the experts, are shown.

3. Results

The modified Delphi method fitted the purpose of the study and was considered to be a convenient procedure by the experts. The individual elicitations lasted from 25 to 98 minutes (overall mean 53 minutes, 47 min for cattle experts and 59 min for swine experts). Two swine experts took the opportunity to write down the following additional measures: "*prevention of contact with birds, no attendance at markets/shows or no return from there, chronology of animal transports, big distance between farm and road, restrictions to workers having been abroad and buying semen only from males with health certificate*". Since these measures were but evaluated by the expert who suggested them, they were not evaluated in the second round nor were they included in the final database. In the second round of the elicitation, experts took the opportunity to reassess their answers. Overall, the ranks for cattle were reduced by 56 score points, ranging from -39 (FMD, expert 1) to +24 (IBR, expert 3) for the assessment of individual diseases by one expert. The overall ranks for swine were raised by 4 score points, varying from -21 (FMD, expert 11) to +8 (PRRS, expert 9) score points. Nevertheless, the reassessment did not result in changes in the median values.

For some measures all experts showed a complete agreement while for other measures a maximal range of 0 – 5 was observed. For cattle farms, experts agreed in "*Prevention of contact with pets"* and measures concerning feedstuff as being of low effectiveness. On the other hand their opinions on the importance of measures concerning feedstuff are divided. A strong disagreement could also be seen for: *"No breeding animals, transport vehicles and equipment shared with other farms"* and "*Limitation of number of animals"*. Swine experts agreed in the assessment of *"Quarantine animals after market/show"* and of "*No breeding animals, transport vehicles and equipment shared with other farms".* On the other hand, *"Geographical barriers*", "*Limitation of number of animals"* and "*Vehicle access restriction"* were assessed dissimilarly. The overall differences in the assessment are shown in Figures 1 and 2. Differences of half points were not common since the instruction for the elicitation was to provide scores from zero to five and not every expert took the opportunity to give half points as well. Of all individual assessments, 67% were not differing more than one, 88% not more than two score points. The degree of disparity in the assessments was comparable for the individual diseases, which indicates that one disease was not discussed more controversially than another.

Cattle experts assessed their knowledge on BT (median 5.5 (range 5-6)) as being the best, followed by BVD (5.25 (5-6)), IBR (5 (4-6)) and FMD (5 (3-6)). Swine experts ranked their knowledge on each disease as follows: EP (5.5 (2-6)), FMD (5 (4-5.5)), PRRS (5 (4-5.5)) to ASF (4.5 (3-5)).

For cattle farms, Spearman's rank correlation coefficient (r_s) showed a strong correlation between the assessment of the effectiveness of measures for BVD and IBR (rho = 0.8). A moderate correlation could be seen between the importance and the effectiveness of measures for BVD (0.6), IBR (0.6) and the overall disease median (0.5). The assessment of the effectiveness of the measures for FMD was also moderately correlated to those for IBR (0.6) and BVD (0.6).

For swine farms, a strong correlation between the assessment of the effectiveness of measures for FMD and ASF (0.8) could be seen. A moderate correlation could be seen between the importance and the effectiveness of measures for ASF (0.6), PRRS (0.6) .The assessment of reliability revealed a weak dependency of the elicitation results on the different experts (ICC expert: 0.05 – 0.36) and a stronger on the individual measures (ICC measure: 0.46 – 0.73) (Table 5).

Three out of four international experts ranked the measures in accordance with the scale of our elicitation. The fourth expert commented on the results. Overall, the four international experts agreed with the assessment of the Swiss experts, with only 8 ranks deviating from the range of scores provided by the Swiss experts (expert1: 5/124, expert2: 3/124, expert3: 0/89). The results of the international experts were not considered for the final assessment, since they were not gained through a modified Delphi method and only refer to the effectiveness but not to the importance of biosecurity measures.

4. Discussion

Expert elicitations are an established method for gathering knowledge in a field where hard data are not available. One of the advantages of the Delphi method (Linstone et al., 2002) is that the experts are questioned independently so that each opinion is weighed equally. Furthermore, the feedback of the group consensus and the possibility to reevaluate own answers minimizes the variance, without risking over- or underweighting individual experts based on their behavior in group discussion. In addition, the modified Delphi method applied in this study brings along the advantages of flexibility and attractiveness, which reduces the chance of non-participation and losing experts in subsequent sessions. In terms of proceeding, the method permits including individual preferences of the experts, without losing consistency of the answers. It is also time- and cost effective for both parties and allows including the experts uncertainty about his estimate. The results of the self-evaluation on the expert's knowledge on the diseases could also be used to weigh the assessment scores of importance and effectiveness (Horst et al., 1996). We decided against it, in the belief that the subjectivity of a self-evaluation outweighs its information content. It was not surprising to see that, endemic and prevailing diseases such as BT and EP were known best, whereas exotic diseases such as ASF were known least. The number of experts who participated in the elicitation was eight for each species. While a higher number of experts would increase power, significance and reliability of the results, this was difficult to achieve in a small country like Switzerland, with a limited number of animal health experts.

In order to screen biosecurity knowledge in Switzerland, the inclusion of experts from various divisions dealing with the interdisciplinary field of animal production, seemed indispensable. The differences in expertise are also reflected in the results of the elicitation. For example scientists working in agriculture valuated measures concerning feedstuff more, scientists working with disease agents in laboratories valuated farm management measures less than the other experts. While a selection of experts from different fields prevents a fragmentary view on biosecurity, it is important that each participating expert at the same time has a broad, solid knowledge on basic principles of this particular field. This aims to prevent a wide range of answers, as was in part the case in this study. By calculating ICC, we investigated the influence of the expert to the variance in scores. We tested the influence of the individual expert and the individual biosecurity measure to an unequal assessment. With the ICC values for the measures consistently being larger, it can be concluded that the variance in scores was influenced more by the question (importance/effectiveness of a particular biosecurity measure) itself, rather than by the personal opinion of the expert. Reasons for different assessments can be differential opinions, task uncertainty or knowledge gaps, as biosecurity is a relatively new term (for an old concept) and only few studies have focused on quantitative aspects of individual biosecurity measures. In addition, the lack of a consistent definition and application of the popular keyword biosecurity might have contributed to the rather wide range of answers provided by the experts.

For some experts the fact that biosecurity includes the prevention of introduction and spread constituted difficulties in the assessment. These difficulties could be avoided by differentiating between internal (the prevention of spread within a herd; sometimes referred to as biocontainment (Graham et al., 2008)) and external biosecurity (the prevention of introduction into a herd), as some authors do (Laanen et al. 2010; FAO 2010; Brennan and Christley 2012). In the present study, this distinction was ignored in the belief that transmission of infectious agents follows the same principles no matter if it is between or within herds. In addition the advantage of keeping the elicitation process shorter, less complex and more attractive to the expert probably outweighs potential imprecision. For the same reason, the number of measures was kept at a reasonable minimum by consolidating formulation of the measures. For example "*minimize purchase and sale of animals*", "*geographical barriers (mountains, rivers,...)*" and "*disposal of carcasses and manure*". Especially with the latter, some experts felt unsatisfied as they saw a greater risk in carcasses than in manure. With having to judge these actually two measures in one, the importance/effectiveness of disposal of carcasses was under- and the disposal of manure overestimated. For more precise results measures should be more specific and single.

The list of biosecurity measures was found to be exhaustive by most experts (14/16). Additional measures were proposed by two swine experts only. Measures concerning artificial insemination were not listed with the idea that sexual contact with a bull or boar is an additional risk for transmitting disease to the semen transferred. Bringing new genetics into a herd always carries the risk of pathogen introduction. Thus reproduction is included in the categories of animal movement, animal contacts and contact to the outside world. The measure "*Quarantine animals after market/show*" was especially difficult to assess for swine experts (3/8 skipped this measure) since it is uncommon in Switzerland to bring pigs back to the holding after attending markets/shows. Furthermore, for biosecurity reasons it would be preferable not to attend markets/shows at all. The same applies to purchase and sale of animals as well as summer pasturing for cattle.

Another difficulty arose by the lack of a common agreement on how a biosecurity measure is defined. "*Geographical barriers*" certainly is not a classic measure, but it contributes to preventing infectious agents from spreading. Also "*minimize purchase and sale of animals*" is sometimes not classified as a biosecurity measure; however it is known to be of major relevance for disease transmission. Furthermore, quarantine is defined as isolation of animals that are either infected or suspected of being so, or of non-infected animals that are at risk (Thrusfield, 2007). Recommendations for implementation vary in duration and degree of separation, thus a general assessment of this measure proves difficult. This is also reflected in the statement of some experts (2/16), that quarantine should be extended to include parturient animals as well and not only sick and newly introduced animals. It is obvious that a commonly accepted definition of biosecurity and (on-farm) biosecurity measures would certainly facilitate future research and discussion on this topic. Only this way, standard lists of evidence-based recommendations can be developed.

The differentiation between importance and effectiveness of the measures was essential for gathering proper data for an applicable biosecurity scoring system. However the distinction proved to be challenging to the experts. To anticipate confusion, both definitions as well as the elicitation procedure were explained orally and were also provided in written form. The possibility to ask questions and for the interviewer to interfere was given all time during the elicitation process. Nevertheless, an inadequate distinction between the two terms could be one of possible reasons for the wide range of the answers provided. In addition, it might have contributed to the high scores for the effectiveness of biosecurity measures, in particular for FMD. Schemann et al. (2012) report that the estimation of the effectiveness of countermeasures is negatively correlated to the potential for aerosol transmission. This could not be confirmed in the present study, in which measures were assessed as being the most effective on FMD virus, a pathogen that can readily be transmitted through the air over great distances (Schley et al., 2009). Since FMD is a highly contagious and a much feared disease, countermeasures are very important, but of limited effectiveness in preventing aerosol spread. On the other hand Schemann et al. provide a possible explanation for the high assessment of the effectiveness of biosecurity measures by the Swiss experts: People who have never experienced a particular disease and do not feel endangered thereof, tend to assess the effectiveness of biosecurity measures higher than people who have experienced an outbreak (Schemann et al., 2012). And Switzerland is officially declared free from five (BT, FMD, ASF, PRRS, IBR) of the seven diseases investigated. The four international experts coming from different countries with dissimilar disease status however agreed with their assessment. The feedback by these experts is a useful addition to the statistical analysis (Horst et al., 1998).

Several biosecurity scoring systems have been developed within the last years (Julio Pinto and Santiago Urcelay, 2003; Laanen et al., 2010; Oidtmann et al., 2011; Van Steenwinkel et al., 2011). For all of them, assigning weight to individual measures was a key point. However, for most biosecurity measures, deciding on a logical weighing principle is hampered by the lack of data (Hagenaars, 2008), thus researchers had but two possibilities: either to weigh all measures equally or to generate new data. Equal weighing poses the risk of under- or overestimating the contribution of certain biosecurity measures in reducing disease transmission. A scoring system for the quantification of the biosecurity status in pig herds was recently developed in Belgium (www.biocheck.ugent.be). This system does not refer to particular diseases and is, with adapted weights for the subcategories, applicable to every type of pig production unit. The weighting is based on published literature on transmission routes for infectious agents and common knowledge on the introduction and spread of animal diseases (Laanen et al., 2010). Measures preventing transmission through direct animal contact were weighed more than those preventing transmission through indirect contact, since animal contact was considered as the most important route of transmission (Amass et al., 2004). The critique, that the selection of measures and the assignment of weights is subjective, is justified but unavoidable (Laanen et al., 2010). This emphasizes the need for further research on the effectiveness of individual biosecurity measures. Alternatively, livestock units can be compared to each other by creating a linear scoring system, instead of defining biosecurity in absolute terms through the use of a quantitative scoring system (Van Steenwinkel et al., 2011).

Our database forms a semi-quantitative biosecurity scoring system based on the effectiveness and on the importance of individual biosecurity measures. The system is designed for the current situation in Switzerland and refers to specific diseases and species only. It can though easily be adapted to any situation and any region worldwide, provided that the importance of biosecurity measures for a given location has been evaluated. On the other hand, the parameters on the effectiveness are pathogen specific. With the availability of appropriate data through literature, expert elicitation or studies, the risk profile can be extended to include other diseases as well. Livestock species are threatened by different diseases and face different risks. The inclusion of additional species in such a system would require an adaptation of the list of biosecurity measures since not all measures are applicable to different species.

The biosecurity scoring system we developed not only permits the comparison of measures to each other but also of farms in absolute terms. It can be used for evaluating biosecurity standards of individual farms and as a decision-support tool for policy makers. Through the input of farm parameters, the benefit gained by improving single measures can directly be calculated. The evaluation of individual farms can be used to allocate them into risk categories. This classification could assist in the planning of risk based inspections and for providing incentives in the agricultural sector. This way, farms with a high standard of on-farm biosecurity would benefit from a lower control frequency and financial rewards for maintaining or improving their current biosecurity status. This will improve resource allocation, while ensuring high standards of animal health.

5. Conclusion

The results from the expert elicitation have highlighted the need for a consistent use of the term biosecurity. Only with this, a fruitful discussion and implementation of biosecurity measures can be realized. This on the other hand is a condition for biosecurity to cope with its use as a popular key word and to form the basis for economic decisions and policy making.

The broad range of the expert opinions can be interpreted as demand for further research in biosecurity. Especially more studies evaluating the effects of individual measures are a challenge that needs to be approached. Furthermore not only scientific data about the importance and effectiveness of biosecurity measures, but also a disciplined compliance, is crucial for an effective biosecurity system. Sound concepts should be developed for as good biosecurity can be practiced at all times, not just during an outbreak.

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In order to improve readability of this article the masculine form was used. It is assumed that this refers to both genders on equal terms. The elicitation was performed on five female and eleven male experts. The four international experts were all males.

References

Amass, S.F., Mason, P.W., Pacheco, J.M., Miller, C.A., Ramirez, A., Clark, L.K., Ragland, D., Schneider, J.L., Kenyon, S.J., 2004. Procedures for preventing transmission of foot-and-mouth disease virus (O/TAW/97) by people. Veterinary microbiology 103, 143–9.

Barceló, J., Marco, E., 1998. ON FARM BIOSECURITY. Available at: http://www.adiveter.com/ftp/articles/articulo31.pdf

Brennan, M.L., Christley, R.M., 2012. Biosecurity on cattle farms: a study in north-west England. PloS one 7, e28139.

Casal, J., De Manuel, A., Mateu, E., Martín, M., 2007. Biosecurity measures on swine farms in Spain: perceptions by farmers and their relationship to current on-farm measures. Preventive Veterinary Medicine 82, 138–50.

Cross, P., Williams, P., Edwards-Jones, G., 2009. Differences in the perceptions of farmers and veterinary surgeons about the efficacy of mitigation strategies for controlling bluetongue. The Veterinary Record 165, 397–403.

Department for Environment, Food & Rural Affairs (DEFRA), 2003. Biosecurity guidance to prevent the spread of animal diseases. Available at: http://www.defra.gov.uk/animal-diseases/biosecurity.

European Commission, 2007. A new Animal Health Strategy for the European Union (2007-2013) where “Prevention is better than cure” Available at: http://ec.europa.eu/food/animal/diseases/index_en.htm.

Fasina, F.O., Ali, A.M., Yilma, J.M., Thieme, O., Ankers, P., 2012. The cost-benefit of biosecurity measures on infectious diseases in the Egyptian household poultry. Preventive Veterinary Medicine 103, 178–91.

Federal Statistical Office (FSO), 2012. Schweizer Landwirtschaft Taschenstatistik 2012. Available at: http://www.bfs.admin.ch/bfs/portal/de/index/themen/07/22/publ.html?publicationID=4710.

Food and Agriculture Organization of the United Nations (FAO), 2010. Good practices for biosecurity in the pig sector – Issues and options in developing and transition countries. FAO Animal Production and Health Paper No. 169.

Federal Veterinary Office (FVO), 2009. Blauzungenkrankheit in der Schweiz. Available at: http://www.bvet.admin.ch/gesundheit_tiere/01973/02437/index.html?lang=de&download=NHzLpZeg7t.

Graham, J.P., Leibler, J.H., Price, L.B., Otte, J.M., Pfeiffer, D.U., Tiensin, T., Silbergeld, E.K., 2008. The animal-human interface and infectious disease in industrial food animal production: rethinking biosecurity and biocontainment. Public Health Reports 123, 282–299.

Hagenaars, T., 2008. Between-farm transmission routes of highly transmissible diseases in livestock: a literature study on the quantitative knowns and unknowns. Central Veterinary Institute of Wageningen report 08/CVI0034.

Hintze, J., 2012. NCSS 8. NCSS, LLC. Kaysville, Utah, USA. www.ncss.com.

Hoe, F.G.H., Ruegg, P.L., 2006. Opinions and practices of wisconsin dairy producers about biosecurity and animal well-being. Journal of dairy science 89, 2297–308.

Horst, H., Huirne, R.B., Dijkhuizen, A.A., 1996. Eliciting the relative importance of risk factors concerning contagious animal diseases using conjoint analysis: a preliminary survey report. Preventive Veterinary Medicine 27, 183–195.

Horst, H., Dijkhuizen, A.A., Huirne, R.B., De Leeuw, P., 1998. Introduction of contagious animal diseases into The Netherlands: elicitation of expert opinions. Livestock Production Science 53, 253–264.

Julio Pinto, C., Santiago Urcelay, V., 2003. Biosecurity practices on intensive pig production systems in Chile. Preventive Veterinary Medicine 59, 139–145.

Laanen, M., Beek, J., Ribbens, S., Vangroenweghe, F., Maes, D., Dewulf, J., 2010. Bioveiligheid op varkensbedrijven: ontwikkeling van een online scoresysteem en de resultaten van de eerste 99 deelnemende bedrijven. Vlaams Diergeneeskundig Tijdschrift 79, 302–306.

Lindberg, A., Houe, H., 2005. Characteristics in the epidemiology of bovine viral diarrhea virus (BVDV) of relevance to control. Preventive Veterinary Medicine 72, 55–73; discussion 215–9.

Linstone, H.A., Turoff, M., Helmer, O., 2002. The Delphi Method Techniques and Applications. Available at: http://is.njit.edu/pubs/delphibook/delphibook.pdf.

Moore, D.A., Merryman, M.L., Hartman, M.L., Klingborg, D.J., 2008. Comparison of published recommendations regarding biosecurity practices for various production animal species and classes. Journal of the American Veterinary Medical Association 233, 249–256.

Morgan, M.G., Fischhoff, B., Bostrom, A., Atman, C.J., 2002. Risk Communication. A Mental Models Approach. Cambridge University Press, Cambridge.

Nöremark, M., Frössling, J., Lewerin, S.S., 2010. Application of routines that contribute to on-farm biosecurity as reported by Swedish livestock farmers. Transboundary and emerging diseases 57, 225–36.

Oidtmann, B.C., Crane, C.N., Thrush, M.A., Hill, B.J., Peeler, E.J., 2011. Ranking freshwater fish farms for the risk of pathogen introduction and spread. Preventive Veterinary Medicine 102, 329–40.

Presi, P., Struchen, R., Knight-Jones, T., Scholl, S., Heim, D., 2011. Bovine viral diarrhea (BVD) eradication in Switzerland — Experiences of the first two years. Preventive Veterinary Medicine 99, 112–121.

Schemann, K., Firestone, S.M., Taylor, M.R., Toribio, J.-A.L.M.L., Ward, M.P., Dhand, N.K., 2012. Horse owners'/managers' perceptions about effectiveness of biosecurity measures based on their experiences during the 2007 equine influenza outbreak in Australia. Preventive Veterinary Medicine 106, 97–107.

Schley, D., Burgin, L., Gloster, J., 2009. Predicting infection risk of airborne foot-and-mouth disease. Journal of the Royal Society, Interface / the Royal Society 6, 455–62.

Shrout, P.E., Fleiss, J.L., 1979. Intraclass correlations: Uses in assessing rater reliability. Psychological Bulletin 86, 420–428.

Snively, D.W., 2001. Biosecurity on the Farm. West Virginia University. Available at: http://www.wvu.edu/~agexten/Biosecure/Farm.pdf.

Thrusfield, M., 2007. Veterinary epidemiology, 3rd ed. Blackwell Science Ltd.

Van Steenwinkel, S., Ribbens, S., Ducheyne, E., Goossens, E., Dewulf, J., 2011. Assessing biosecurity practices, movements and densities of poultry sites across Belgium, resulting in different farm risk-groups for infectious disease introduction and spread. Preventive Veterinary Medicine 98, 259–270.

World Animal Health Information Database (WAHID), 2012. Animal Health Information. Available at: http://www.oie.int/wahis_2/public/wahid.php/Countryinformation/Animalsituation.

Wells, S.J., 2000. Biosecurity on dairy operations: hazards and risks. Journal of dairy science 83, 2380–6.

Table 1 On-farm biosecurity measure categories and corresponding median values of importance and effectiveness for cattle

Category	Number of measures	Importance	Effectiveness BT	Effectiveness BVD	Effectiveness FMD	Effectiveness IBR
animal movements	5	4	2	4	3	4
animal contacts	4	2	1	2	2	3
farmers / workers	2	3	1	3	4	3
visitors	3	4	0	3.5	4	3.5
vehicles	3	4	1	2.5	4	3
stable	2	2.75	2	0	1	0.5
feedstuff	2	1.5	0	0	0	0
disease awareness	2	5	4.25	4	4.5	4
reduction of infection pressure	4	3.5[1]	2	2	3	2
contact to the outside world	4	1	3	1	3	1

[1] Without vaccinations. Value including vaccinations: 2

Table 2 On-farm biosecurity measure categories and corresponding median values of importance and effectiveness for swine

Category	Number of measures	Importance	Effectiveness ASF	Effectiveness EP	Effectiveness FMD	Effectiveness PRRS
animal movements	5	5	5	4	4	5
animal contacts	2	3	2.5	3	2	2
farmers / workers	2	4	4	3	4	4
visitors	3	4	4	3	4	4
vehicles	3	4	4	3	5	4
stable	3	4	2.75	2	2	3
feedstuff	2	1	1	0	1	1
disease awareness	2	4	4	3	4	4
reduction of infection pressure	4	3.5[1]	2.25	2	3	3
contact to the outside world	4	4	4	4	4	5

[1] Without vaccinations. Value including vaccinations: 1.25

Table 3 **Results of an expert elicitation on the importance and effectiveness of different on-farm biosecurity measures. Median and range values of the answers of Swiss cattle experts are shown.**

Biosecurity measure	**Importance**	**Effectiveness on**			
		BT[a]	**BVD**[b]	**IBR**[c]	**FMD**[d]
Minimize purchase and sale of animals	3 (2.5 – 4)	2 (0 – 3)	4 (3 – 5)	3.5 (2 – 5)	3.5 (1 – 5)
Purchase from farms with known disease status or health certificate	4 (3.5 – 5)	3 (1 – 5)	5 (5)	5 (4 – 5)	4.25 (3 – 5)
Quarantine facility for sick animals and new arrivals	4.25 (3 – 5)	2 (0 – 3)	3.5 (2 – 5)	3.75 (2 – 5)	3 (2 – 5)
Quarantine animals after market/show	2.75 (1 – 4)	1 (0 – 3)	3 (1 – 5)	3.5 (2 – 5)	4 (2 – 5)
Closed Herd or all-in-all-out replacement	2.5 (2 – 4)	1 (0 – 2)	2.5 (1 – 5)	3 (0 – 5)	2 (0 – 5)
Separation of pastures of neighboring farms	2.5 (0 – 4)	0 (0 – 1)	4 (1 – 5)	3.25 (1 – 5)	2.5 (0 – 4)
Measures (Testing, only healthy animals on summer pasture) for common summer pastures	4.25 (4 – 5)	2 (1 – 3)	5 (5)	4 (3 – 5)	3 (0 – 4)
Prevention of contact with wild animals	1.5 (0 – 2.5)	1 (0 – 2)	1 (0 – 3)	1.5 (0–3.5)	3 (1 – 4)
Prevention of contact with pets	1 (0 – 2.5)	0 (0 – 1)	0 (0 – 1)	0 (0 – 1)	0 (0 – 2)
Farmer / Worker has no contact with cloven-hoofed animals from other farms	2.5 (1 – 4)	0.5 (0 – 2)	3 (1 – 4)	3 (1 – 4)	4.75 (3 – 5)
Personal working hygiene of farmer/worker (boots, clothes, hands,…)	5 (2 – 5)	1 (0 – 2.5)	3.5 (2 – 5)	2.5 (2 – 5)	2.75 (1 – 5)
Access restriction for visitors	3.75 (1 – 4)	0 (0 – 1)	1.5 (0 – 3)	3.25 (0 – 5)	3.5 (1 – 5)
In-house or clean boots and clothes for non-professional visitors	4 (2 – 5)	0 (0 – 1)	4 (1 – 5)	3.25 (1 – 5)	4 (2.5 – 5)
Personal working hygiene of professional visitors (boots, clothes, hands,...)	5 (3 – 5)	0.5 (0 – 1)	4.5 (3 – 5)	3.75 (2 – 5)	4.5 (2.5–5)
Vehicle access restriction	2.25 (0 – 4)	0 (0 – 1)	1 (1 – 3)	1.5 (0 – 3)	4 (2 – 5)
Animal transport vehicle leak-proof	4 (1 – 5)	1 (0 – 1)	2 (2 – 4)	3.75 (0 – 5)	3.5 (2 – 5)
Cleaning and disinfection of the vehicle	4.75 (4 – 5)	1 (0 – 2)	4 (3 – 5)	3.75 (2 – 5)	4.5 (2 – 5)
Arthropod control	3 (0 – 4)	4.75 (3 – 5)	0 (0 – 1)	0.5 (0 – 2)	1 (0 – 2)
Rodent control	2.25 (0 – 3)	0 (0 – 1)	0 (0 – 1)	0.5 (0 – 2)	1 (0 – 4)
Treatment of feedstuff (chemically, physically)	0.5 (0 – 5)	0 (0 – 1)	0 (0)	0 (0 – 1)	0.5 (0 – 1)
Storage of feedstuff dry and protected	2.5 (0 – 5)	0 (0 – 1)	0 (0 – 1)	0 (0 – 1)	0 (0 – 1)
Education for animal keepers (raising disease awareness)	5 (3 – 5)	5 (3.5 – 5)	4.5 (4 – 5)	4 (3 – 5)	4.5 (2.5–5)
Animal health monitoring by the farmer	4.5 (3 – 5)	3 (2.5 – 5)	4 (2 – 5)	3.5 (2 – 5)	4.5 (2.5–5)
Limitation of number of animals	1.75 (0 – 5)	1.5 (0 – 5)	1 (0 – 4)	0 (0 – 4)	2.5 (0 – 4)

Good health management	4.5 (3 – 5)	3 (1 – 5)	3 (2 – 5)	3 (1 – 5)	3 (2 – 5)
Disposal of carcasses and manure	4 (2 – 5)	1 (0 – 2)	2.5 (0 – 5)	1.5 (0 – 5)	3 (1 – 5)
Closed housing	1 (0 – 3)	4 (3 – 5)	1 (0 – 2)	1 (0 – 4)	3.5 (0 – 5)
Geographical barriers (mountains, rivers,...)	0 (0 – 4)	2.75 (0.5–5)	0.5 (0 – 1)	1 (0 – 4)	2.5 (0 – 5)
Low animal density in the area	2 (0 – 3.5)	3 (0 – 5)	2 (0 – 3)	0.5 (0 – 2)	3 (0 – 4)
No breeding animals, transport vehicles and equipment shared with other farms	2.5 (0 – 4)	1 (0 – 5)	4 (0 – 5)	4.5 (3 – 5)	4.5 (0 – 5)
BT-Vaccination	1.5 (0 – 4)	5 (4.5 – 5)			
BVD-Vaccination	0 (0)		1 (0 – 4)		
IBR-Vaccination	0 (0)			2 (1 – 5)	
FMD-Vaccination	0 (0)				4 (3 – 5)

The scale ranged from 0 - 5.
[a] Bluetongue (BT)
[b] Bovine viral diarrhea (BVD)
[c] Infectious bovine rhinotracheitis (IBR)
[d] Foot and mouth disease (FMD)
Measures showing a strong agreement (maximal 1 score of difference) are depicted in light grey shadows, whereas measures showing a maximal disagreement (0-5) in dark grey shadows

Table 4 **Results of an expert elicitation on the importance and effectiveness of different on-farm biosecurity measures. Median and range values of the answers of Swiss swine experts are shown.**

Biosecurity measure	Importance	Effectiveness on			
		ASF[a]	EP[b]	FMD[c]	PRRS[d]
Minimize purchase and sale of animals	3.5 (2 – 5)	4.5 (3 – 5)	4 (3 – 5)	5 (3 – 5)	4.5 (3 – 5)
Purchase from farms with known disease status or health certificate	5 (2 – 5)	5 (3 – 5)	5 (4 – 5)	5 (3 – 5)	5 (3 – 5)
Quarantine facility for sick animals and new arrivals	5 (4 – 5)	4 (2 – 5)	4 (3 – 5)	4 (1 – 5)	5 (3 – 5)
Quarantine animals after market/show	5 (4 – 5)	5 (4 – 5)	5 (4 – 5)	5 (4 – 5)	5 (5)
Closed Herd or all-in-all-out replacement	4 (2 – 5)	5 (3 – 5)	4.5 (4 – 5)	4 (3 – 5)	5 (4 – 5)
Prevention of contact with wild animals	4 (2 – 5)	5 (3 – 5)	5 (3 – 5)	3 (1 – 5)	2.75 (0 – 5)
Prevention of contact with pets	2.5 (0 – 4)	1 (0 – 2)	1 (0 – 3)	1 (0 – 4)	2 (0 – 4)
Farmer / Worker has no contact with cloven-hoofed animals from other farms	3.75 (2 – 5)	4.5 (3 – 5)	4 (2 – 5)	4.5 (3 – 5)	4 (2 – 5)
Personal working hygiene of farmer/worker (boots, clothes, hands,…)	4 (2 – 5)	3 (2 – 5)	3 (2 – 4)	3.5 (1 – 5)	4 (3 – 5)
Access restriction for visitors	3.25 (2 – 5)	3 (1 – 5)	2 (0 – 3)	4 (2 – 5)	3.5 (1 – 5)
In-house or clean boots and clothes for non-professional visitors	3.25 (2 – 5)	3.5 (1 – 5)	2 (1 – 5)	3.5 (2 – 5)	3 (2 – 5)
Personal working hygiene of professional visitors (boots, clothes, hands,...)	4 (4 – 5)	4 (3 – 5)	3 (3 – 5)	4 (2 – 5)	4.5 (3 – 5)
Vehicle access restriction	2 (0 – 5)	4 (1 – 5)	2 (1 – 5)	4.5 (3 – 5)	4 (1 – 5)
Animal transport vehicle leak-proof	4 (3 – 5)	4 (2 – 5)	2.5 (0 – 5)	5 (3 – 5)	4 (2 – 5)
Cleaning and disinfection of the vehicle	4.75 (3 – 5)	5 (3 – 5)	4 (3 – 5)	5 (3 – 5)	5 (3 – 5)
Cleaning and disinfection of the compartments following animal replacement	4 (2 – 5)	2 (1 – 3)	2.75 (2 – 4)	1.5 (1 – 4)	2.5 (1 – 4)
Arthropod control	3 (2 – 4)	3 (1 – 5)	1.5 (0 – 4)	3 (0 – 4)	3 (1 – 4)
Rodent control	4 (2 – 5)	2.75 (0 – 4)	1.5 (0 – 4)	2 (1 – 4)	2 (0 – 4)
Treatment of feedstuff (chemically, physically)	1 (0 – 3)	1 (0 – 5)	0 (0 – 1)	1.5 (0 – 5)	1 (0 – 2)
Storage of feedstuff dry and protected	1.5 (1 – 5)	1 (0 – 2.5)	0 (0 – 1)	1 (0 – 3)	1 (0 – 1)
Education for animal keepers (raising disease awareness)	4 (2 – 5)	4 (1.5 – 5)	3.5 (2 – 5)	4 (3 – 5)	4 (3 – 5)
Animal health monitoring by the farmer	4 (1.5 – 5)	4.5 (1 – 5)	3 (1.5 – 5)	3.5 (2 – 5)	4 (2 – 5)
Limitation of number of animals	2 (0 – 5)	1.5 (0 – 4)	4 (0 – 5)	2 (0 – 3)	3 (0 – 4)
Good health management	3.75 (2 – 5)	2 (1 – 4)	3 (0 – 5)	2.5 (1 – 4)	4 (2 – 5)

Disposal of carcasses and manure	4 (2.5 – 4)	3.5 (2 – 5)	1.5 (0 – 3)	4 (1 – 5)	2.75 (1 – 5)
Closed housing	3 (0 – 5)	4 (3 – 5)	3.5 (2 – 5)	4 (3 – 5)	4.5 (2 – 5)
Geographical barriers (mountains, rivers,...)	2 (0 – 5)	2.5 (0 – 4)	4 (2 – 5)	3 (0 – 5)	4.25 (0 – 5)
Low animal density in the area	3.75 (2 – 5)	3 (0 – 5)	4 (3 – 5)	4.5 (2 – 5)	4.5 (2 – 5)
No breeding animals, transport vehicles and equipment shared with other farms	4.75 (4 – 5)	5 (4 – 5)	5 (4 – 5)	5 (4 – 5)	5 (5)
EP-Vaccination	0 (0 – 1)		2 (0 – 4)		
FMD-Vaccination	0 (0 – 1)			4 (4)	
PRRS-Vaccination	0 (0 – 1)				2.5 (1 – 4)

The scale ranged from 0 - 5.
[a] African swine fever (ASF)
[b] Enzootic pneumonia (EP)
[c] Foot and mouth disease (FMD)
[d] Porcine reproductive and respiratory syndrome (PRRS)
Measures showing a strong agreement (maximal 1 score of difference) are depicted in light grey shadows, whereas measures showing a maximal disagreement (0-5) in dark grey shadows

Table 5 **Intraclass Correlation Coefficient for expert and measure showing their influence on the assessment of on-farm biosecurity measures**

		ICC expert	ICC measure			ICC expert	ICC measure
	Importance	0.099	0.508		Importance	0.049	0.464
cattle	BT	0.286	0.729	swine	ASF	0.169	0.510
	BVD	0.088	0.708		EP	0.160	0.550
	IBR	0.278	0.631		FMD	0.288	0.488
	FMD	0.360	0.553		PRRS	0.122	0.484
	Median diseases	0.280	0.628		Median diseases	0.124	0.516

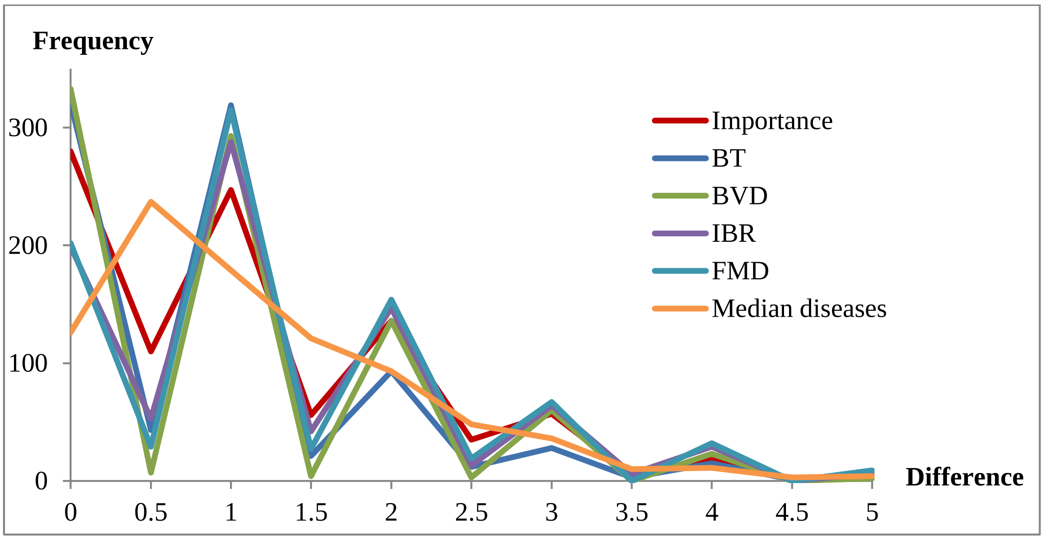

Fig. 1*: Dimension and frequency of different assessments of 31 biosecurity measures by 8 Swiss cattle experts. Shown are the differences in scores for the assessment of the importance of biosecurity measures in Switzerland, as well as of the effectiveness of biosecurity measures on BT, BVD, IBR and FMD and on a calculated median value of the four diseases.*

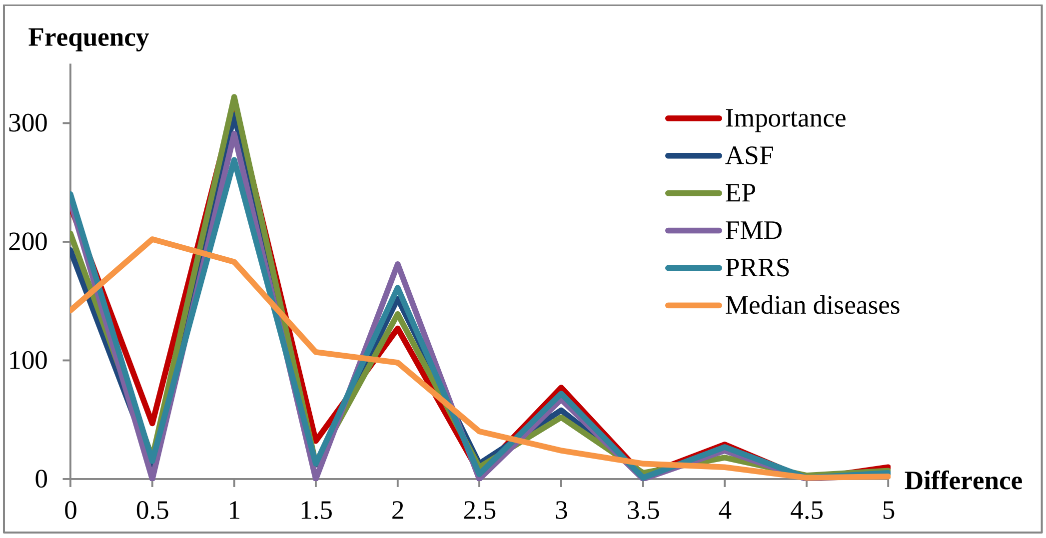

Fig. 2*: Dimension and frequency of different assessments of 30 biosecurity measures by 8 Swiss swine experts. Shown are the differences in scores for the assessment of the importance of biosecurity measures in Switzerland, as well as of the effectiveness of biosecurity measures on ASF, EP, FMD and PRRS and on a calculated median value of the four diseases.*

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