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ABSTRACT

Traditional indicator-based livestock surveillance has been focused on case definitions, definitive diagnoses and laboratory confirmation. The use of syndromic disease surveillance would increase the population base from which animal health data is captured and facilitate earlier detection of new and re-emerging threats to animal health. Veterinary practitioners could potentially play a vital role in such activities. In a pilot study, specialist private veterinary practitioners (PVPs) working in the English pig industry were asked to collect and transfer background data and disease incidents reports for pig farms visited during the study period.

Baseline data from 110 pig farms were received, along with 68 disease incident reports. Reports took an average of approximately 25 minutes to complete. Feedback from the PVPs indicated that they saw value in syndromic surveillance. Maintenance of anonymity in the outputs would be essential, as would timely access for the PVPs to relevant information on syndromic trends. Further guidance and standardisation would also be required.

Syndromic surveillance by PVPs is possible for the pig industry. It has potential to fill current gaps in the collection of animal health data, as long as the engagement and participation of data providers can be obtained and maintained.

INTRODUCTION

Animal disease has a significant economic impact on livestock production (1); disease events are monitored – and subsequent action taken – to protect the health of both the livestock and the humans who work with or consume them. Public health surveillance is the continuous, systematic collection, analysis and interpretation of health-related data needed for the planning, implementation and evaluation of public health practice (2). The same definition applies to veterinary public health surveillance (3). Beyond the level of the individual animal or production unit, surveillance programmes may be implemented and administered at population level by government, veterinary or industry bodies, or a combination of these (4). Surveillance data can be obtained by various means, may be required for a number of different purposes and outputs can take varying formats, dependent on the needs of the end-users.

Monitoring of livestock health often takes place at slaughter (5,6). Whilst of value, this point of data gathering and collation has limitations. These include: the historical nature of such observations; the data gathered only include clinically healthy animals and lack specificity; information from on-farm incidents and fatalities are omitted and data come too late to take action to improve the sampled animals' health. Conversely, data generated by laboratory diagnostic submissions (known in the United Kingdom (UK) as scanning surveillance) are based on submissions from animals of any age that are showing clinical signs (7). Such submissions may lead to accurate diagnoses and identification of specific pathogens, enabling action to be taken to control disease. Disease diagnosis data may be used to identify trends and changes in submission numbers and diagnostic rates over time. Analysis of submission data by clinical syndrome and presenting sign is also valuable, including where a diagnosis is not reached (8). However, private veterinary practitioners (PVPs) submit only a subset of clinical cases for laboratory investigation. Hence, many disease events will not be included by the scanning surveillance system in place. The passive surveillance "pyramid" analogy describes this (9). Data are collated and analysed ultimately from just that fraction of all livestock health events at the top of the pyramid, from which diagnostic submissions are made to participating laboratories (Fig. 1). Although there are systems in place to collate laboratory data for monitoring trends over time (7,10), or to detect unusual disease occurrence (11), the absence of systematic recording and collation of disease data from livestock populations attended to by veterinary practitioners means that this resource remains untapped. Syndromic surveillance offers the potential to fill this gap. In the past, in the UK, the National Animal Disease Information Service (NADIS) collected such data from sentinel vets (12), however it was discontinued.

Syndromic surveillance enables the early identification of the impact – or absence of impact – of potential threats by (near) real-time collection, analysis, interpretation and dissemination of health-related data (13). Alternatively, it can be viewed as a surveillance approach that uses health-related information that precedes, or substitutes for, formal diagnosis (4). By definition, usually syndromic surveillance will not yield the specific confirmed diagnoses that are typically provided by laboratory diagnostic submissions; specificity is forgone in favour of greater sensitivity. The focus is on clinical syndromes: groups of signs relating to particular physiological systems and related proxy measures, such as mortality or production loss. The principle of syndromic surveillance is that, even without a definitive diagnosis, identifying unusual occurrence or levels of disease syndromes could indicate an emerging issue of potential significance for animal or public health; i.e. it offers the opportunity for earlier disease detection and mitigation.

This paper describes a pilot study in collaboration with a group of specialist PVPs working in the English pig industry. The study was based on the assumption that PVPs could perform a key function in collecting data to contribute to the early detection of animal disease events. PVPs are familiar with the typical health picture on their clients' premises and are generally the primary contact point for health concerns that cannot be managed by the client alone. There are additional requirements for those pig producers involved in assurance schemes to undergo regular veterinary visits to inspect the health status of their livestock. In 2010 92%

of UK pig meat production was reported to be governed by quality assurance schemes requiring quarterly veterinary visits (14). If during these visits health data were to be recorded and centrally collated, they could prove a valuable source of additional information on pig health. There are examples of how a system like this could work (15–17). In Great Britain (GB), an interface system is in use in which veterinary practice records are extracted directly into companion animal disease surveillance databases (16–19). In the Netherlands, five items of pig health data are recorded at each monthly pig farm visit through an on-line application (15). In the UK pig sector, however, the range of different recording systems currently in use by pig PVPs presents a challenge to implementing any similar system to the companion animal disease surveillance databases (16,17). The Dutch system (15) provides less frequent and less detailed information for syndromic surveillance.

The aim of this pilot study was firstly to evaluate whether pig PVPs working in England would be able to gather and submit data gathering at a syndromic level, secondly to gain experience of how PVP-provided data could be collected, analysed, interpreted and reported in anonymised form, so that it was of value to the end-user and finally to identify the constraints that would need to be addressed if such a system were to be implemented at national level as an animal health monitoring and syndromic surveillance programme.

MATERIALS AND METHODS

The pilot study consisted of a short trial (May to July 2013) with PVPs working in areas with high pig population in England.

Development of data recording templates

The project team, which included two pig PVPs, created standardised data recording templates: one to provide baseline information describing the pig unit (i.e. the farm) and one for reporting a disease incident. Different design approaches were taken, reflecting the fact that although a single, one-off unit baseline assessment was likely to be sufficient for a given unit, there may be multiple occasions on which a PVP would need to generate a disease incident report for that same unit. The draft templates were reviewed at a standardisation day by the PVPs who were going to use them and amended as necessary (e.g. definition of disease incident was refined in accordance with to the opinions of the PVPs). For both templates, the data entry systems were developed to standardise recording terms and to minimise error, e.g. by use of multiple-choice drop-down menus or single-choice selection options, error messages if inserting incorrect data and use of the data validation option in Microsoft Excel (Microsoft Corporation 2010). Provision was made for additional text comments by reporting PVPs.

Baseline assessments

Pig unit baseline assessment templates specified the data to be recorded once for each unit participating in the pilot study. These baseline data comprised the veterinary and unit identifier (including unit county location) and 12 additional questions about background data on the health/disease status of a pig production unit against which clinical syndromes can be reported. These included: demographic information, such as unit purpose and size; management type and pig accommodation; vaccination status and the unit health status for *Mycoplasma hyopneumoniae*, porcine reproductive and respiratory syndrome, swine dysentery and mange.

Disease incident reports

Disease incident report templates were made accessible via a secure internet server run from Scotland's Rural College (SRUC) to only those PVPs participating in the study. A disease incident report was required on any occasion that a PVP was asked to advise on a disease occurrence that was above the typical background level of disease on the pig unit. The following guidelines were given to the PVPs to assist them in determining whether or not to report a disease event as a disease incident:

> "A disease incident report should be generated if there is a change in clinical signs and/or mortality beyond the background for the pig unit (i.e. different to what is usual

> for that unit based on the PVP's existing knowledge of their clients' stock, the unit and the industry), which is remarkable to the attending PVP. The report may be of a disease incident that has been ongoing for some time before first being discussed with the PVP at, for example, a quarterly visit. The report should include both suspected upsurges/recrudescence of clinical signs/diseases known to be an issue for the farm and also possible new disease incidents. The determining factor for a report being generated is that the PVP considers the clinical signs/disease to be above the 'norm' for the pig unit, this would suggest an intervention was likely to be considered. If in doubt, PVPs should report disease incidents."

The disease incident report comprised the date and type of contact (e.g. routine visit, disease investigation, off farm discussion) and 19 further questions to characterise the incident. The information recorded included: age(s) of affected pigs; stage(s) of production; morbidity and mortality; predominant clinical signs and their duration; suspected clinical syndrome; whether the disease incident was a new disease/pathogen or a resurgence of a disease/pathogen already present on the unit; whether or not a provisional diagnosis was made. Changes in productivity were also a valid trigger for a disease incident report. To capture these changes, reportable clinical signs included poor growth and infertility.

Five additional questions were sent to each PVP to follow up on all reported disease incidents. This was done two weeks after the report, to determine whether or not a diagnosis had been reached (and if so what it was) and whether the disease incident had resolved or was still causing concern.

Study design and data collection

A convenience sample of PVPs was selected based on the following criteria: a) specialised pig veterinarians working in England and b) willingness to participate in the study. The selected PVPs were asked to attend a training and standardisation day (spring 2013). Here they were briefed on the aims, methodology and reporting requirements of the study, to ensure a standardised approach. They were also given the opportunity to suggest changes to the proposed templates. Six PVPs attended that meeting and a further two were briefed individually with the same material on other dates before the start of the study. For the study, each PVP was assigned a unique identifier; known only to the PVP and to project team members. Similarly, each pig unit was assigned a unique identifier known only to the PVP responsible for that pig unit. These veterinary and pig unit identifiers were used for all data recording throughout the study to maintain confidentiality.

Data collection took place over a six-week period between May 29th and July 12th 2013. Each PVP was asked to send all disease incident reports (and the corresponding pig unit baseline assessment data) for at least three consecutive weeks of work falling within the six-week study period. This was to allow for other PVP commitments, while ensuring a focused reporting period from each participant. The aim was to obtain at least 10 routinely visited units per participating PVP, across a range of breeding and rearing pig unit types. This value was chosen based on practicality: it was assumed that in a three week period each PVP would make at least 10 routine farm visits for quality assurance purposes.

Completed unit baseline assessments were submitted to the project team via email; disease incident reports were uploaded via the secure server. Only the project team had access to the data received. The approach to data recording and transfer was considered, as well as how to report outcomes to PVPs and producers (as possible primary target end-users).

PVP feedback

The PVPs were encouraged to correspond with the project team during the study for clarification of reporting requirements, or other queries, where necessary. Feedback was also elicited via SurveyMonkey (SurveyMonkey Inc) after the end of the study period. In this questionnaire PVPs were asked about issues relating to the unit identifiers, time required to complete the reports, questions that should be added, removed or modified, the data collection process, the guidance offered and the usefulness of the exercise. Comments and post-study feedback from the participating PVPs also contributed to the evaluation phase of this study.

RESULTS

Eight PVPs contributed data to this study. The target of at least 10 baseline assessments per participating PVP was achieved by all but one PVP. One hundred and ten unit baseline assessments (range 5-23 per participating PVP) and 68 disease incident reports (range 2-19 per participating PVP) were completed during the study. Of the 110 unit baseline assessments, 81 were completed at routine visits, with the remainder being associated with a PVP having to deal with a disease incident. Some problems were encountered when collating and analysing the data, particularly in relation to non-response. In some instances this could be solved by inclusion of an "unknown" option in the drop-down menu. There were other considerations that could be solved in future systems by implementation of cross-validation between questions and by not allowing the user to progress if certain fields were left blank.

Types of data collected

In the study population, breeder-to-finisher and finisher units were the most common unit type (Table 1). The farms in the study were from several counties of England with almost 25% from the Yorkshire region. Continuous flow systems were more commonly used for growing pigs than all-in/all-out systems (Supplementary material – Table S2). Three quarters (75%) of disease incidents were reported in post-weaned pigs (Supplementary Material – table S9). For most of the disease incidents reported (55.9%) clinical signs had been ongoing in the unit for more than two weeks (Supplementary material – Table S11). Around 53% of the disease incidents reported were considered to be resurgence of a disease/pathogen already believed to be present on the unit, i.e. showing recurrent issues in the units (Supplementary Material – Table S13). The majority of the incidents were reported during routine visits (54.4%) or off farm discussions (29.4%) (Supplementary Material –Table S7). For breeding animals the clinical disease syndromes that were often reported were reproductive and systemic, while for growing animals they were gastrointestinal, respiratory and skin syndromes (Figure 2, Supplementary Material Table S19)). A provisional diagnosis was made in the great majority of the incidents reported (91.2%) (Supplementary material Table S20) and in almost half of the incidents reported the disease has resolved at the time of follow-up (Supplementary Material Table S22). More detailed results are presented in Supplementary Material.

The data were used to develop mock-ups of potential outputs for reporting, e.g. at county level (Supplementary material Figure S1 to S7). Baseline assessments were essential to provide background data for these potential outputs (Figure 3).

Table 1: Type of units (number – N and percentage - %) that participated in the study

Unit type	**N**	**%**
Breeder-finisher	33	30
7kg weaner producer	16	14.5
30kg weaner producer	7	6.4
Nursery	6	5.5
Nursery-finisher	16	14.5
Finisher	29	26.4
Gilts unit	2	1.8
Boar stud	1	0.9

PVP feedback on the pilot study

The average time taken to complete a unit baseline assessment and disease incident report was 22 minutes (range 6-60 minutes) and 27 minutes (range 10-60 minutes) respectively. The PVPs stated that the some data requirements needed clarification, in particular, what constituted a disease incident that needed to be reported. The follow-up questions after submission of a disease incident report were deemed to be a burden, as their value was not always apparent. However the PVPs involved in this study indicated from the outset that the value of this type of syndromic surveillance is significantly enhanced if there is timely provision of relevant surveillance information back to participating veterinarians and their clients, whilst maintaining anonymity in outputs.

DISCUSSION

This pilot study evaluated whether the gathering and submission of syndromic level data by pig PVPs working in England in the context of their routine veterinary work was possible. It also identified a number of potential constraints that would need to be addressed if such a system were to be introduced nationally. Overall the study has demonstrated that data collection by pig PVPs is possible and provided information about key requirements needed for a functional syndromic surveillance system.

Baseline assessments are essential to provide background data on the health/disease status of a pig production unit against which syndromic disease can be reported (e.g. Figure 3 and FigureS6 – Supplementary Material). There is a risk of reduced compliance if PVPs feel that the requirements of any syndromic surveillance system duplicate data recording already performed (20). In this pilot study it was demonstrated that these data could be collected by PVPs at routine quarterly assurance visits and, if necessary i.e. where they were not collected at a previous quarterly visit, at the same time as a disease incident. Similar requirements exist for pig production in other countries; for example, the Danish Product Standard for pigs delivered to Danish Crown abattoirs (21). In the UK, there might be potential for streamlining the collection of baseline data direct from assurance schemes themselves, instead of collecting stand-alone assessments. Issues of suitability of the data, data sharing, permissions and system compatibilities would all need to be addressed.

The disease incidents reports, on the other hand, capture the data that are key to the implementation of a syndromic surveillance system. The definition of what constituted a disease incident is a subjective measure and therefore introduces observer bias to disease incident reporting. This issue was noted during a study in Ontario (20), where there were differences in how participant veterinarians defined a new incident of disease, despite provision of documented guidance before the study began. It does, however, take into account that different units will have different incident rates due to their production system and husbandry practices. For example: it would not be possible to establish a single acceptable mortality rate for all pig production systems. If a syndromic surveillance system was to be developed for nationwide implementation, further investigation would be required to develop a definition for disease incident that would be acceptable industry-wide. A starting point could be to review the literature and engage pig veterinary practitioners through focus groups. Indeed, after completion of this pilot study, several meetings were held with potential collectors and end-users of these type of data, at which it was suggested that percentage of morbidity is recorded for disease incidents). Although participating PVPs were requested to record all disease incidents that met the project criteria, it is not possible to know if the number recorded was the same as the disease incidents they came across during the study period. Even allowing for an increased effort due to the study's short duration and the novelty value of being involved in this pilot study, the number of disease incidents submitted was a positive outcome. It shows it was possible for most of the PVPs to record the data requested plus it supports the hypothesis that PVP syndromic surveillance could augment existing approaches to animal health surveillance.

The quality and completeness of data collected enabled a descriptive analysis of the types of units experiencing disease incidents during the study period and the types of disease syndromes reported (see Supplementary Material). Given the limitations of the scale of this pilot, it was not expected that the data collected would be representative of the English pig population. Nevertheless most of the farms in the study were located in known pig dense areas of England (e.g. Yorkshire) (22). The disease syndromes recorded were also similar to what would be expected for breeding (reproductive syndrome) and growing pigs (gastrointestinal and respiratory syndromes) (Supplementary Material -Table S12) and to what has been observed elsewhere (15).

PVP input to design and review of recording templates

To confirm a need for the type of surveillance proposed, to optimise buy-in amongst participants and to gain from their experience of gathering pig health information, the participating PVPs were involved in the design and review of the recording templates. This early consultation identified potential constraints in advance: lack of veterinary time, payment for veterinary time, standardisation of recording, coverage of the pig population (geographic and unit type) and concerns about pig farmer/practitioner confidentiality. These were addressed before starting the active data collection phase. Similar constraints have been reported in other studies (23,24). All are pertinent to the concept of PVP-based surveillance, for practical reasons and/or because they have a direct impact on data quality and representativeness. The value of including practitioners in the design stage of a surveillance scheme is corroborated by other studies; in Ontario to examine compliance within practitioner-based surveillance (25) and in Denmark to establish an equine health database (26). The authors of the Canadian study commented that restriction of the available options for data recording and completion not only runs the risk of reduced compliance, but may lead to participation bias (25). There is a view that syndromic surveillance based on the collation of data that are already routinely gathered will lead to more effective compliance (15, 16, 26). While there are clear advantages in obtaining added value from available data, it has been demonstrated in this pilot study that early inclusion of PVPs in the development of templates and methods for recording for data collection can generate the desired results (19). There are however caveats associated with issues to do with the practicality of implementation and scale; so far feasibility has only been demonstrated on a relatively small scale.

PVPs feedback on the pilot study

The average time for recording disease incidents was longer than desirable according to the PVP feedback. The same issue was noted by Hartig and colleagues (23), where equine veterinarians reported being willing to spend a maximum of five minutes to acquire background information on a patient and two minutes to entering patient data into a database. This could be solved by reducing the number of questions in the disease incident report, as is being done in a similar Dutch system (15) and/or by improving the technology for data capture. As previously discussed, the PVPs felt constrained by their need for clarification on what constituted a disease incident that needed to be reported. Another constraint was the perceived burden of the follow-up questions. Further exploration of how to clearly explain to participants and facilitate their understanding of the purpose and necessity of follow-ups to disease incident reports will be vital, as recording whether a diagnosis has been established and/or whether the disease incident has resolved will contribute to determining whether a new or emerging disease could be involved. If PVP-based data collection for syndromic surveillance is to become more widely adopted, these perceived constraints must be addressed.

Engagement with data providers and end-users

Understanding what motivates data providers and end-users and devising appropriate incentives to maintain their engagement to report disease over long periods is essential in developing sustainable, dynamic and adaptable surveillance systems (24). Relevant and timely feedback is a non-monetary incentive that may enhance willingness and overcome the inertia to report (23,24), consequently improving data quality. The PVPs involved in this study indicated from the outset that the value of this type of syndromic surveillance is significantly enhanced if there is timely provision of relevant surveillance information back to participating veterinarians and their clients, while maintaining confidentiality. The potential reporting options explored in this pilot study allow anonymity while maximising the reported information in an interactive way. Monetary incentives were raised in this pilot study during the design phase in the form of a desire for payment for data collection time and this may have implications for scaling up to a wider system. Hartig and colleagues (23) reported that some veterinarians raised concerns related to being charged to be able to access data they have collected; while other stakeholders have shown some reluctance to pay for access to the data. In the pilot study, participants were not asked who should finance such a potential scheme nor if they were willing to pay for access and data extracts. As part of the development of any larger scale, wider system, the questions of “Who benefits?” and “Who pays?” will need to be addressed (3).

Potential alternative systems

In this study we trialled data recording for potential use within a syndromic surveillance system in the pig sector by PVPs, as there is a strong case for specific collation of data directly from PVPs. Nonetheless, data collection by PVPs has a cost. One way to reduce duplication of effort and avoid unnecessary burden on data providers would be to develop an interface between the software used by producers/practitioners during their daily activities and the software used to record syndromic surveillance data (28). This could overcome issues of delay in data transmission, as well as acting as a central data collation and analysis hub. The British companion animal sector has two such systems; however there are still many challenges to be overcome before this can be achieved in the livestock sectors. An alternative approach would be to reduce and prioritise the additional recording required, for example, in the Netherlands only five items of pig health data are recorded at monthly visits via an online application.

This short-term pilot was undertaken to: evaluate whether pig PVPs would be able to gather and submit data at a syndromic level in a timely manner; assess how such data could be collected, analysed and reported and to identify the primary constraints for implementation on a larger scale, such as national level.

Although the system piloted here could not be implemented as a functional, sustainable system in the long term, the findings provide information about key needs for the direction of future development such a system. It also provides evidence with which to approach and inform potential funders and contributors. It has contributed to a syndromic surveillance workshop in 2016 (29) and to applications for developing a relevant app for syndromic surveillance data collection from veterinary practitioners.

CONCLUSIONS

This study has demonstrated that the capture of standardised animal health data by pig PVPs is feasible and has the potential to contribute to syndromic surveillance. It has also highlighted key requirements that can help developing a future sustainable system. These are data design (i.e. what is essential to be captured), which will then impact on practicality (time and effort) for collecting such data; reporting requirements (i.e. what is going to be done with the data – how and when?) and an IT support infrastructure in a secure user-friendly system. Together with assurance of confidentiality, all of these considerations should be explored in collaboration with data providers and end-users. This will drive long-term participation and engagement, by monetary and/or non-monetary reward. The ability to provide timely and relevant information back to data providers and to other stakeholders, such as those involved in national surveillance, is key to achieving buy-in from both producers and practitioners. These topics should be the focus for future research in this area.

FIGURE LEGEND

Figure 1. The surveillance pyramid. This reflects the potential for syndromic data gathered by veterinary surgeons to augment existing surveillance capabilities, which typically rely on definitive diagnoses and laboratory testing (adapted from (30)).

Figure 2. Number and proportion of predominant clinical disease syndrome reported for growing pigs in the study.

Figure 3. Potential output: proportion (and number) of disease incidents reported to be respiratory syndrome in growing pigs per type of unit.

LIST OF ABBREVIATIONS

GB – Great Britain

IT – Information technology

PVP – Private veterinary practitioner

SRUC – Scotland's Rural College

UK – United Kingdom

DECLARATIONS

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

The anonymised datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no financial or non-financial competing interests in relation to this work.

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AUTHORS' CONTRIBUTIONS

*CCG and MKH contributed equally to this research paper.

CCG was involved in developing the concept, the template for the field trial, the standardisation day, the website creation, collating the data, analysis of the results, interpretation of the results and writing the manuscript.

MKH was involved in operational aspects of the collation of field data. She originally drafted and wrote the manuscript.

SW was involved in developing the concept, the template for the field trial, the standardisation day, developing the questionnaire for the PVP feedback, interpretation of the results and contributed to the manuscript.

RMI contributed to the writing of the manuscript.

GJG was involved in acquiring the funding and read the manuscript.

NW was involved in developing the templates for the field trial, organised the standardisation days, participated in the field trial and red the manuscript.

MCW was involved in the development of the templates for the field trial, participated in the field trial and red the manuscript.

SCT provided leadership in the original development of the programme of work, subsequent management, direction and epidemiological oversight of the field study and contributed substantially contributed to the writing of the manuscript.

All authors have read the final manuscript.

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