

Scotland's Rural College

Review of pig health and welfare surveillance data sources in England and Wales

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1 Review of pig health and welfare surveillance data sources in England and 2 Wales

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15

16 **Abstract**

17 The capability to set baselines and monitor trends of health and welfare conditions is an important
18 requirement for livestock industries in order to maintain economic competitiveness and sustainability.
19 Monitoring schemes evaluate the relative importance of conditions so that: appropriate actions can be
20 determined, prioritised and implemented; new and (re)emerging conditions can be promptly detected and
21 the effectiveness of any actions can be measured. In 2011, the national pig levy board published a
22 strategy document highlighting health and welfare conditions of importance to the pig industry that were
23 to be targeted for control. In this study, existing schemes that could be used to monitor or set baselines
24 for these conditions in pigs were reviewed, in order to evaluate their suitability for this purpose, using a
25 standardised surveillance evaluation framework (SERVAL). The schemes included: government-funded
26 surveillance of endemic and exotic disease and pig welfare; industry surveillance of endemic diseases;
27 regional schemes for improving pig health; national accreditation schemes; and information collected by
28 retailers, private veterinary practices and private laboratories. The evaluation of each scheme highlights
29 its capability to monitor any of the targeted conditions. This study identifies the biases, strengths and
30 gaps in each scheme and provides discussion of opportunities for future development.

31

32 **Introduction**

33 The improvement of pig health and welfare is fundamental to securing the sustainability of the pig industry
34 in Great Britain. Disease causes significant cost to pig farmers, limits productivity, and is inextricably
35 linked to pig welfare. Zoonotic diseases also have implications for public health. The costs to the farmer
36 are associated with pig mortality, treatment, control (improved biosecurity, medicine use, cleaning and
37 disinfection, increased labour), reductions in food conversion efficiency and daily live weight gain, and
38 increased carcase condemnation at the abattoir. The full economic impact is usually difficult to estimate,
39 as it is often complicated by multifactorial pathogen involvement and the variety of different disease
40 control measures tailored to each farm. A number of studies have tried to estimate these costs, which can
41 be substantial, for a variety of diseases including swine dysentery and Enzootic Pneumonia (EP) [1-4].
42 The costs of improvement and maintenance of high welfare standards can also be considerable [5-6].

43

44 The implementation of measures to improve pig health and welfare, whilst ensuring the sustainability of
45 the industry, is at the forefront of current initiatives to reduce antimicrobial use [7]. However, to identify
46 where action should be focussed, and to monitor the effectiveness of initiatives, veterinarians, pig

47 keepers and the pig industry require an effective surveillance system. At national level, industry needs to
48 know the baseline status of animal health and welfare and to monitor changes that occur. This assists in
49 the evaluation of the relative importance of diseases and conditions so that appropriate actions can be
50 determined, prioritised and implemented. In addition, the effectiveness of such actions can then be
51 measured. Industry and Government needs prompt detection of new and (re)emerging threats to pig
52 health and welfare and a robust surveillance system that underpins assurance of notifiable disease
53 freedom and international trade agreements.

54
55 Examples of pig health and welfare monitoring programs elsewhere include the Animal Health
56 Surveillance System in the Netherlands, which was designed in 2003 to combine data from multiple
57 sources to meet many surveillance requirements [8]. Another example is the Danish Integrated
58 Antimicrobial Resistance Monitoring and Research Program (DANMAP). This was set up in 1995 to
59 monitor antimicrobial consumption and resistance in bacteria from animals, food and people [9].

60
61 In 2011, the national pig levy board, AHDB-Pork (Agriculture and Horticulture Development Board; known
62 as BPEX at the time of this study) launched a strategy for the British pig industry for the coming decade:
63 the BPEX 20:20 Pig Health and Welfare Strategy [10]. Health and welfare conditions of most importance
64 to the pig industry were identified for control. The areas of welfare focus were tail biting, tail docking, teeth
65 clipping, lameness, freedom around farrowing, husbandry of entire males over 80 kg, pre and post
66 weaning mortality. The areas of pig health and food safety focus identified were *Ascaris suum*,
67 *Brachyspira hyodysenteriae* (swine dysentery), *Mycoplasma hyopneumoniae* (enzootic pneumonia),
68 *Actinobacillus pleuropneumoniae* (APP), Porcine Reproductive and Respiratory Syndrome Virus
69 (PRRSv), lesions at slaughter (as recorded by the British Pig Health Scheme), sarcoptic mange,
70 methicillin resistant *Staphylococcus aureus* (MRSA), *Salmonella* in pig meat, condemned pig meat (kg/
71 pig) and antimicrobial usage. No centralised system for data collection of all of these health and welfare
72 issues existed at the start of the study and the challenge was how could prevalence or occurrence of
73 these pathogens and conditions be monitored to assess control and progress towards the BPEX 20:20
74 Vision outcomes.

75
76 In England and Wales, data collected at different levels (farm, abattoir, laboratory etc) of the pig industry
77 were of variable availability, quality and coverage and their potential use at national level had not been
78 explored. A limited number of English data sources have been previously assessed for general
79 surveillance purposes [11]. In that study, SWOT (strengths, weaknesses, opportunities, threats) analysis
80 was used to assess four monitoring schemes: the British Pig Health Scheme (BPHS), the National Animal
81 Disease Information System (NADIS), the Zoonoses Action Plan (ZAP) for *Salmonella* and APHA's
82 Veterinary Investigation Diagnosis Analysis (VIDA). At the time of this study (2012-2013), two of the four
83 assessed datasets (NADIS and ZAP) were no longer in operation. It was clear that a review with a larger
84 scope was needed, to both determine what data sources existed and which were most appropriate for
85 monitoring pig health and welfare conditions, identified in the BPEX 20:20 Vision outcomes.

86
87 Standardised reviews of surveillance systems are rarely published in the literature, especially those
88 relevant to animal health and welfare. Their focus is predominantly on the ability of surveillance schemes
89 to detect new and exotic diseases [12], or on their uses for detecting bioterrorism [13]; an exception being
90 the evaluation of health and production recording of the dairy cattle population in Great Britain [14].

91
92 The study described here provides a review of data sources relating predominantly to endemic disease
93 and welfare conditions of importance to the pig industry, as defined by the BPEX 20:20 Vision. It also
94 demonstrates the use of a recently developed standardised evaluation methodology tool [15] to assess

95 characteristics, such as the proportion and diversity of the pig industry covered by each scheme. The
96 methods, outcomes, highlights and recommendations of the critical evaluation are presented within the
97 context of the requirements of the BPEX 20:20 Vision.

98

99 **Materials and Methods**

100

101 Information Gathering Framework (IGF)

102 Potential sources of pig health or welfare data were identified that met the criteria of being from sources
103 no older than 2004 which included pigs. Potentially useful sources were identified through a literature
104 review and by contacting industry experts, academic colleagues and contacts within the Animal and Plant
105 Health Agency (APHA), AHDB, Food Standards Authority (FSA), and the Pig Health and Welfare Council
106 Surveillance Subgroup. The data sources did not have to be originally designed for monitoring or
107 surveillance purposes.

108

109 A set of headings was agreed under which information would be collated for each identified data source.
110 These included: population coverage, what health and welfare data were collected, how the data were
111 currently used and factors relating to the usefulness and suitability of the scheme for analysis (e.g. how
112 were farms identified in the scheme, issues with accessibility). Collecting this information involved either
113 contacting staff responsible for the schemes, or collecting information from reports and/or websites.
114 Where possible, it also included the collection of data summaries, or example sets of raw data, to enable
115 preliminary assessment. There was little recorded information about the data collected by private
116 veterinarians and so a web-based questionnaire (SurveyMonkey Inc., Palo Alto, California, USA) was
117 sent to veterinary practitioner members of the Pig Veterinary Society, from which 20 responses were
118 received. Each data source was assessed to determine the likely usefulness of the data and whether
119 more detailed SERVAL evaluation was merited.

120

121 Critical assessment of the data sources

122 The SERVAL evaluation framework [16] was used for those data sources that justified full evaluation. The
123 framework guides the collection of key information on each data source including the processes of data
124 generation, collection and management, system design and management and the wider context within
125 which the systems operate. The SERVAL framework is flexible enough to allow the evaluation of a large
126 range of surveillance schemes for various different outcomes.

127

128 The master list of 22 defined SERVAL attributes was reviewed to select those that were essential to the
129 planned evaluation, and a final list of 13 was selected (Table 1). These attributes were assessed for each
130 data source by the authors and given a score of 1 (excellent) to 3 (poor) [15].

131

132 Additionally, comprehensive information was collected on each data source to define the type of
133 surveillance, the target population, potential threats that might affect use and the key strengths and
134 weaknesses defined by the assessment of the attributes. A 'strong' system, for our purposes, would
135 include those that had: a clearly defined aim and purpose; good coverage; standardised, validated
136 measurements; simple and easy data capture; centralised electronic data management and storage;
137 accessible data with appropriate analysis; timely reporting; clear identifiers to assist linkage to other data
138 sets; documented biases (if present) and which had been established for a number of years. Also, a
139 strong system would document and minimize changes to the surveillance methods. The information was
140 collated from the IGF and/or through additional communication with the data source contacts as well as
141 by additional analysis of any data that were obtained.

142

143 **Table 1:** Description of the 13 selected attributes used to review surveillance data sources (for further
 144 description please see the SERVVAL framework: [16].

Attribute	Description
Benefit	Direct and indirect advantages of the system.
Bias	Ability of the scheme to reflect the true prevalence of a condition in the entire pig industry.
Communication	Evaluation of the information produced and accessibility to such information.
Coverage	Proportion of the population of interest covered.
Data analysis	Whether the scheme uses, or could use, appropriate analysis methods
Data collection	This covers evaluations of the methods of data collection e.g. use of case definition, effective sample size, standard approaches to collection of data.
Data completeness and correctness	Proportion of intended data that is collected.
Historic data	Quality, quantity and availability of historical data
Impact	Use of scheme e.g. ability to use data to drive action.
Representativeness	Sectors of the pig industry covered by the scheme (e.g. breeding pigs).
Sensitivity	Sensitivity of detection of health and welfare conditions e.g. laboratory test sensitivity or evaluation of ability of assessors to detect abattoir lesions.
Specificity	Specificity of detection of health and welfare conditions
Stability/sustainability	Whether system has been stable over time and whether it will remain in the current format in the future.

145

146 **Results**

147

148 Identification of data sources

149 A total of 45 data sources were identified that could potentially be used for health and welfare monitoring
 150 of trends (Final Report to AHDB, Annex 6, 2013, details available from the corresponding author). These
 151 included government sources of endemic and exotic disease and welfare surveillance (e.g. VIDA);
 152 industry surveillance of endemic diseases (e.g. BPHS, Wholesome Pig Scheme, Qbox); schemes for
 153 improving regional pig health (Pig Health Improvement Project (PHIP)); accreditation schemes (e.g.
 154 Quality Assurance, organic accreditation, Freedom Foods); health and welfare research studies; retailer,
 155 private vet, company or pig farm data sources; sample testing by private laboratories; fallen stock data;
 156 and antimicrobial sales data. Reasons that data sources did not progress to a full evaluation included the
 157 source only covering Scottish farms; covering too few farms; or collecting data on conditions outside of
 158 the BPEX 20:20 Vision.

159

160 SERVVAL assessments

161 Of the pig health and welfare data sources identified, 11 were selected for appraisal using the SERVVAL
 162 framework (Table 2). The evaluations are presented in Table 3, with information provided on which BPEX
 163 20:20 conditions could be monitored by these sources in Table 4. All data sources for England and Wales
 164 differed in relation to their surveillance objectives, structure and operation and their attributes scores were
 165 diverse. All but the Red Tractor scheme, data from private laboratories and veterinarians were highly
 166 scored against the 'Benefit' attribute (Table 1) indicating the advantage of the current use of the data
 167 collected by these schemes. All of the data sources reported biases and potential issues. Each SERVVAL
 168 assessment is discussed (as it existed at the time of this review in 2012-13) in detail below.

169

170 **Table 2.** Description of each data source, assessed as a potential source of pig health and welfare
 171 surveillance, using SERVAL.

Data source	Source Type	Target population	Inspection type	Inspection performed/ Data provided by
Antimicrobial sales	Government	All pharmaceutical companies supplying UK food and non-food animals	Data collection	Pharmaceutical companies
APHA cross-compliance welfare	Government	Subset of pig premises in GB	Visual inspection	Govt veterinary and animal health inspectors
BPHS	Industry	Selected batches of slaughtered pigs from members in England and Wales	Visual inspection	Veterinary practitioners
FSA Ante-mortem/ Post-mortem inspections	Government	All slaughtered pigs for human consumption in England and Wales	Visual inspection	Meat inspectors
PHIP	Industry	All commercial pig farms in England	Data collection	Veterinary practitioners
Private laboratories	Industry	All pig premises in GB	Various sample types	Private laboratory staff
Private veterinary practices	Industry	All commercial pig units in GB	Data collection/ visual Inspection/ sample collection/ post mortems	Veterinary practitioners
Red Tractor	Accreditation scheme	All commercial pig farms in GB	Data collection/ visual Inspection	Veterinary practitioners, scheme inspectors
Real Welfare	Industry	All pigs on commercial units in England and Wales	Visual Inspection	Veterinary practitioners
Retailers	Industry	All pig units supplying the relevant retailers in GB	Data collection/ visual inspection	Meat inspectors, farm inspectors
VIDA	Government	All farms with livestock attended by veterinarians in GB	Various sample types and post-mortems	Veterinary practitioners and Veterinary Investigation Officers

172 UK: United Kingdom; GB: Great Britain.

1 **Table 3.** The summary of evaluation of each animal health surveillance system against 13 selected attributes and health and welfare factors from
 2 the BPEX 20:20 Vision using the SERVAL framework.

Data source	Attributes												
	Benefit	Bias	Communication	Coverage	Data analysis	Data collection	completeness and correctness	Historic data	Impact	Representativeness	Sensitivity	Specificity	Stability/sustainability
<i>Antimicrobial sales</i>	1	2	1	1	2	2	2	1	2	3	N/A	N/A	1
<i>APHA cross-compliance welfare</i>	1	2	2	3	2	2	1	2	2	1	2	1	2
<i>BPHS</i>	1	2	2	1	1	1	2	1	2	2	2	1	1
<i>FSA Ante-mortem/ Post-mortem inspections</i>	1	2	2	1	1	1	2	2	1	2	2	1	3
<i>PHIP</i>	1	3	2	2	3	2	3	3	2	2	2	2	2
<i>Private laboratories</i>	2	3	3	2	3	3	3	2	3	3	2	2	3
<i>Private veterinary practices</i>	2	2	3	1	N/A	2	2	2	1	1	2	2	2
<i>Red Tractor</i>	2	2	3	1	1	1	2	2	2	2	2	2	2
<i>Real Welfare</i>	1	2	2	1	2	1	1	2	2	2	1	1	2
<i>Retailers</i>	1	2	3	2	3	1	3	2	2	2	2	2	1
<i>VIDA</i>	1	3	1	2	2	2	2	1	1	3	2	2	2

3 Key to surveillance system performance against each attribute: (1) Excellent or very good; (2) Good, although with some room for improvement; (3) Poor, in need
 4 of attention. [15]. N/A – not evaluated.

5

- 1 **Table 4.** Summary of whether each animal health surveillance system can be used for monitoring (marked with an x) for 20 key health and welfare
 2 factors identified in the BPEX 20:20 Vision.

BPEX 20:20 Vision: areas of health and welfare focus	Antimicrobial sales	APHA cross-compliance welfare	BPHS	FSA Ante-mortem/Post-mortem inspections	PHIP	Private laboratories	Private veterinary practices	Red Tractor	Real Welfare	Retailers	VIDA
(a) tail biting		x	x	x				x	x	x	
(b) tail docking		x						x	x		
(c) teeth clipping								x			
(d) freedom around farrowing		x						x			
(e) lameness				x			x		x	x	
(f) husbandry of entire males > 80kg											
(g) pre-weaning mortality							x				
(h) post-weaning mortality							x				
(i) swine dysentery (<i>Brachyspira hyodysenteriae</i>)					x		x	x			x
(j) Sarcoptic mange			x		x		x				x
(k) <i>Mycoplasma hyopneumoniae</i>			x	x	x	x	x	x			x
(l) <i>Actinobacillus pleuropneumoniae</i>			x	x		x	x				x
(m) PRRS					x	x	x	x			x
(n) <i>Ascaris suum</i>			x	x			x				x
(o) post-mortem lesions			x	x						x	x
(p) condemned pig meat kg/pig in abattoirs										x	
(q) antimicrobial usage as mg active/kg pig meat	x										
(r) Methicillin-resistant <i>Staph.aureus</i>											
(s) <i>Salmonella</i> in pig meat (re: EU reduction targets)											

1 Government schemes (details accurate at time of study 2012-13):
2 1. VIDA: The VIDA database records disease diagnoses and surveillance data generated by diagnostic
3 submissions to the Government-funded scanning surveillance network. Diagnostic samples (e.g. serum,
4 blood, nasal swabs, faeces) including live or dead pigs for post-mortem examination, are submitted to APHA
5 and SAC veterinary investigation centres by private veterinary surgeons from any type of pig holding,
6 including pet and smallholder pigs. However, the representativeness of the whole pig population is low
7 (score 3) with most submissions being from commercial growing pigs and fewer submissions are received
8 from small or 'breeding-only' holdings or areas of low pig farm density [17]. Data captured includes the farm
9 and submitting veterinary practice details, purpose of the livestock holding, age, sex, accommodation of the
10 pigs, nature and duration of clinical signs, samples submitted, tests performed, clinical syndrome involved
11 and diagnoses made. Quarterly reports are published online [18]. VIDA includes several diseases caused by
12 pathogens specified in the 20:20 Vision (Table 4), and is thus of importance for contributing to monitoring
13 trends in the diagnostic rate of these diseases. It is recognised that for certain diseases, like mange and
14 "milk spot" caused by *Ascaris suum*, few VIDA diagnoses are made as this is often diagnosed in veterinary
15 practices, at slaughter, or at private laboratories without need for samples to be sent to VIDA. *Salmonella*
16 infection is recorded in VIDA only when it is causing disease, and isolations are also reported to Defra as
17 part of the Zoonoses Order 1989 requirements. However, there is no routine screening for *Salmonella*
18 infection from diagnostic submissions and these are from diseased pigs of any age. In addition, they are not
19 representative of healthy finisher pigs at slaughter, thus VIDA does not contribute to monitoring *Salmonella*
20 in pig carcasses which is delivered to meet EU legislation by food business operators at slaughter. VIDA
21 diagnoses are allocated according to strict diagnostic criteria agreed nationally (specificity score 1) and only
22 from disease-associated incidents, thus for example, the isolation of *Salmonella* or detection of PRRS virus
23 in the absence of relevant clinical signs or pathology is not recorded as a diagnosis. Data from samples sent
24 from healthy pigs for monitoring purposes are not included. VIDA data is from a biased population as
25 submissions are likely to come from pigs with more unusual, severe or unresponsive disease presentations,
26 thus the data can be used to assess trends in diagnostic rate, but not directly for disease prevalence (bias
27 score 3). In addition, veterinarians are not obliged to submit samples or pigs to VIDA and can use
28 commercial laboratories which do not, at present, provide data to VIDA. VIDA data can be viewed as having
29 high accuracy of diagnosis but the scheme scored 2 for sensitivity due to the variability of detection for some
30 of the wide variety of pathogens covered by the scheme. The stability of the scheme is good with reference
31 to the diagnostic criteria and training of staff and the scheme has been operating since 1975 (historical data
32 score 1). However, the number and type of submissions are influenced by several variable factors including:
33 disease occurrence, awareness of disease threats, and the economic prosperity of pig production, which is
34 itself particularly affected by feed and pig prices, with the effect of some of these factors hard to quantify [19].
35
36 2. FSA ante-mortem and post-mortem inspections: This scheme provides surveillance for conditions of public
37 or animal health significance and the monitoring of animal welfare. This is achieved through ante-mortem
38 and post-mortem inspection at abattoirs. The recording of specified conditions is a statutory requirement at
39 each slaughterhouse [20]. Although this scheme mostly records data from finisher pigs, a strength is that all
40 slaughtered pigs are assessed (coverage score 1). At the time of assessment by this study, the list of
41 relevant conditions covered by this scheme included tail bite, lameness (inferred from foot lesions, joint-leg
42 lesions and others not defined), milk spot (localised and generalised), and post-mortem lesions of the heart,
43 liver and kidney. The scheme also reports pneumonia with or without abscessation and with or without
44 pleurisy, which could be indicators of *M. hyopneumoniae* and APP infection, but are not specific for either.
45 Although the scheme has been in place for many years, the electronic recording of findings is relatively
46 recent and the list of conditions recorded has changed many times. This affects the stability of the scheme
47 (score 3). The scheme scored 3 for completeness and correctness due to issues with identifying pigs from
48 the same batch and lack of routine data cleaning and checking. Although there are details of diagnostic
49 criteria for some conditions, there is little evaluation of the ability of inspectors to detect and identify specific
50 conditions. It is believed that severe cases may be detected, but that less severe cases may be missed,
51 especially in a busy slaughterhouse.
52

1 3. APHA cross-compliance welfare inspections: The surveillance of welfare standards on pig farms is
2 completed via a system of regular visits to farms by trained APHA inspectors (either veterinary staff or animal
3 health officers). Cross-compliance is the set of conditions which must be met by farmers who claim
4 payments under the Common Agricultural Policy (CAP) (such as the Single Payment Scheme). This would
5 indicate a high representativeness of farms in England and Wales (score 1). As the inspections are statutory,
6 they include farms that might not contribute data to other schemes or projects. Each year a minimum of 1%
7 of pig farmers subject to cross-compliance are inspected indicating poor coverage (score 3). The selection of
8 farms to visit is 80% risk-based (based on risk factors, such as those farms infrequently visited by APHA
9 inspectors for other reasons) and 20% randomised, indicating potential for sampling bias. Additional reactive
10 visits also take place but are not covered here due to differences in data collection. On-farm assessments
11 are made of staffing, staff inspection of animals, disease treatment, records, housing, environment, freedom
12 of movement, feed and water, breeding procedures, space, and implementation of specified interventions
13 e.g. tail docking. Each are scored from A, indicating compliance with legislation and code of
14 recommendations, to D, indicating non-compliance with legislation with unnecessary suffering. Information is
15 also collected on actions and bans, which are recorded in a central database (data completeness score 1).
16 Although this scheme could in theory be useful to collect some of the welfare conditions detailed by the
17 20:20 Vision, a score of non-compliance does not provide information on which specific problems were
18 detected.

19
20 4. Antimicrobial sales: The Veterinary Medicines Directorate (VMD) collects and publishes annual figures on
21 the volume of UK sales of antibiotics authorised for use in animals. Antimicrobial sales other than antibiotics
22 are also reported (e.g. anti-fungus, coccidiostats, anti-protozoals). The annual report published online [21] is
23 based on sales data provided by the veterinary pharmaceutical companies under a statutory requirement
24 since 2005 and therefore the coverage of data collection is assumed to be very good (historical data and
25 coverage scores of 1). Sales of antibiotics are shown: per chemical group (active ingredient); by route of
26 administration (medicated foodstuff, oral/water, injectables, intra-mammaries, others) and as overall sales by
27 animal species for which the antibiotics are licenced. Data on pig demographics from Defra's June Census
28 and the average weight at time of treatment per species provided by the European Medicine Agency (EMA)
29 are used to calculate what is known as the Population Correction Unit (PCU): the total tonnes of animal for
30 each species at time of treatment. The total quantity of antibiotic sold divided by the PCU provides a value
31 enabling a year-on-year comparison between countries using the same methodology: quantity of antibiotics
32 used (in mg) by weight of animals at time of treatment (in kg). The results may not provide an accurate
33 indicator of clinical disease as some sales may be used prophylactically to prevent the establishment of
34 disease, which is reflected in the poor representativeness score. This scheme could support the collection of
35 data on the use of antimicrobials; an identified goal in the 20:20 Vision. However, a key weakness of the
36 data is that it cannot identify the target species for which the antimicrobials were used, as many products are
37 authorised for use in more than one animal species with a substantial number of products licensed for use in
38 both pigs and poultry.

39
40 Farm accreditation schemes (details accurate at time of study 2012-13):

41 1. The Red Tractor Quality Assurance (QA) scheme: Data are collected from member pig farms to ensure
42 required quality standards are maintained. It was estimated that 85% of pigs were covered by the scheme in
43 2012-13, as most commercial producers raising pig for slaughter require membership to access accredited
44 slaughterhouses. The sampled population is unlikely to include non-commercial and specialist breeder pig
45 farms, but would provide very good coverage of commercial pigs destined for slaughter (score 1).
46 Information is gathered during quarterly veterinary visits and annual visits carried out by a QA auditor. Data
47 are entered onto a central database, with simple descriptive analyses carried out for reporting purposes
48 (data analysis and collection scores of 1). Within data relating to farm management, some procedures of
49 relevance to the BPEX Vision outcomes are included such as teeth clipping, tail docking, ear notching and
50 tattooing. The recording system registers the estimated number of pigs affected by these four conditions
51 under five categories (0, 0-10, 10-50, 50-90, >90%) and describes the portion of tail removed if docking is
52 performed. Information on the use of farrowing crates is also included. Information on EP, PRRS and swine

1 dysentery is restricted to recording farm-level presence or absence of infection. However, there are issues
2 related to data completeness and variability in recording of information from each visit, although systems to
3 improve data checking have been added (score 2).

4
5 Industry schemes (details accurate at time of study 2012-13):

6 1. Pig Health Improvement Project (PHIP): This AHDB project was phased out in 2012 but at the start of the
7 study the scheme aimed to promote sharing of pig farm health status data for specified pathogens in
8 England and Wales alongside a regional mapping system. The idea was to assist farms in the same
9 geographic region to share information and understand and tackle disease risks at a local level. The focus
10 was on four causes of disease: *Mycoplasma hyopneumoniae*, PRRSV, *Brachyspira hyodysenteriae* and
11 *Sarcoptes* species (mange mites), with the scheme monitoring disease presence rather than identifying the
12 pathogens. Data on each pig farm's infection status was recorded by vets, if the farm owner gave
13 permission. They were only accessible to those working on the project, the farmers themselves and their
14 veterinarians, unless farmers agreed to share their information with others within their regional cluster. The
15 disease classifications were based on the attending veterinarian's opinion supported by guidance documents
16 to help standardise responses, as a pilot study showed that the veterinary opinions showed good correlation
17 with diagnostic results. The scheme was voluntary and, although open to anyone, mainly represented
18 commercial farms within the main pig-producing regions of England, thus biasing data at national level. The
19 scheme was only in existence for a short period and so there was little historical data to allow temporal
20 analysis. Furthermore, the completeness of the data was reported to be suboptimal with initial engagement
21 waning in part due to pathogen mapping not being fully developed (historical data and data completeness
22 scores of 3). Although the scheme was phased out, aspects were incorporated into the broader disease
23 prevention and control within AHDB [22].

24
25 2. British Pig Health Scheme (BPHS): This slaughterhouse surveillance scheme provided pig health and
26 welfare information inferred from abattoir lesions. It has helped farmers and vets monitor conditions to inform
27 management decisions. This is a voluntary scheme, led by AHDB, collecting post-mortem lesion data on
28 thirteen gross lesions observed in slaughtered finisher pigs: peritonitis, pericarditis, hepatic scarring, papular
29 dermatitis, tail damage, EP-like lung lesions, viral-like lung lesions, acute pleuropneumonia-like, chronic
30 pleuropneumonia-like, pleurisy, milk spot, abscess and pyaemia [23]. The scheme covers several areas of
31 BPEX 20:20 Health/Disease focus. Assessments are completed quarterly on batches of at least 50 pigs from
32 each member farm, by trained veterinary inspectors. Problems with consistency are possible, due to
33 differences between assessments carried out by different vets and at different abattoirs, although to aid
34 standardisation the scheme includes benchmarking exercises, regular staff training and data analysis to
35 compare assessors. BPHS is a fully electronic scheme with good coverage of the commercial fattening pig
36 production (data collection, data analysis and coverage scores of 1). However, as diseased animals and
37 breeding pigs are not included this limits the representativeness (score 2). Anecdotal evidence suggests that
38 time limitations may impact upon assessment so that not all conditions present are recorded, and difficulties
39 with batch identification may be encountered at some abattoirs; these may cause errors in estimating
40 condition occurrence. The scheme has been running since 2005 providing a stable and useful dataset
41 (historical data and stability scores of 1). However, there is a risk that the scheme could be discontinued if
42 funding from AHDB or industry partners is removed.

43
44 3. Real Welfare scheme: This scheme was designed and is managed by AHDB. The scheme provides a
45 standardised and validated method (sensitivity and specificity scores of 1) to collect information on welfare
46 conditions from a representative proportion of growing pigs over 50kg and sows on participating farms [24].
47 Real Welfare involves on-farm assessment of pig welfare using a set of five objective and repeatable
48 measures involving the observation of pigs. These data allow benchmarking and comparison between units.
49 Data are collected by vets during routine visits two to four times a year, depending on the operation of the
50 farm. The number of pigs assessed is between 300 and 900 a year, according to the size of the farm.
51 Inspections were designed to be representative across a farm. At the time of the assessment (2012-2013),
52 the scheme was only in its second year with limited coverage thus the lack of historical data would limit its

1 use for temporal trend analysis, but the scheme was to be rolled out through the Red Tractor scheme to its
2 members as a requirement (which will provide a coverage score of 1). The scheme does not evaluate
3 welfare at boar, piglet or weaner level, limiting how representative it is of the overall pig population. The
4 areas of BPEX 20:20 Vision Welfare outcomes covered by this scheme are tail biting, tail docking and
5 lameness. However, the scheme may underestimate prevalence of tail biting and lameness as the
6 assessment excludes pigs hospitalised, culled or dead due to these conditions.
7

8 4. Private veterinary practices (PVP): Data may be collected on pig health and welfare and vaccines and
9 antimicrobial treatments prescribed from routine quarterly, emergency and other visits to pig farms, as well
10 as information from off-farm contact with farmers. These contacts are privately-funded by the farmer, unless
11 the pigs are owned by a company with in-house veterinarians. Information about farm status for certain
12 pathogens, clinical signs and diagnoses are usually recorded. However, accessibility is problematic as there
13 is not currently a common database or template for farm reports etc used by different veterinarians and
14 veterinary practices, nor is there a ready means of extracting relevant data from the diverse methods of data
15 recording (communication score 3). Confidentiality concerns are also present. Coverage and
16 representativeness are high (scores of 1) for commercial pig farms, with quality assured pig farms being
17 visited routinely on a quarterly basis as described above, although less regular visits to non-commercial
18 herds would also be included. The recorded data includes visit reports, laboratory tests (in-house and
19 external), action plans, performance data, post-mortem examination reports, medicine lists and veterinary
20 health plans. Another concern over the use of these data for surveillance is the lack of standardisation of
21 recording between practices with some information well-collated across practice or company but data on
22 diseases diagnosed/ clinical signs are poorly standardised. Data from telephone or e-mail contact is only
23 regularly recorded by approximately 25% of those responding to the web-based survey of specialist pig vets.
24 Electronic recording and storage of the reports and records was reported to occur by most (80%) of survey
25 respondents.
26

27 5. Private (commercial) veterinary laboratories: these may be used by veterinarians attending pig premises
28 for a range of diagnostic tests on samples they submit. The number and type of pig samples (blood, post-
29 mortem tissue, nasal swabs, faeces) received by private laboratories varies, as do the range of tests for pig
30 pathogens offered (stability score 3). Most of the tests offered relate to the more common endemic
31 pathogens and several are included in the BPEX 20:20 Vision, namely: *Ascaris suum*, *Mycoplasma*
32 *hyopneumoniae*, APP, PRRS and mange, but not *Brachyspira hyodysenteriae*. Bacteriological culture is
33 offered by some and in theory could be used for detection of *Salmonella* in slaughter pigs, although it is
34 unlikely to be used. There is generally a smaller dataset of information collected from each submission
35 compared with VIDA, with submitting veterinary practice and farm details recorded, but the latter probably
36 not with sufficient detail to localise farm premises. There may be no surveillance information beyond knowing
37 the testing required, while detection of pathogens in a laboratory report does not necessarily equate with
38 diagnosis of disease. There is no standardised system used by all the different laboratories to collate sample
39 and background information (data collection score 3). Similarly the provision of results is also not
40 standardised across laboratories i.e. whether an interpretation of the test results is provided. In general, the
41 laboratories only use the data generated to compile summaries for internal logistical and supply purposes
42 (data analysis score 3). Identifying the number of samples from, and results for, different farms may be
43 problematic from these summaries as a single sample from 100 farms would not be distinguished from 100
44 samples from the same farm, making it difficult to calculate prevalence. Submissions to laboratories is
45 voluntary and influenced by various factors including quality, price, speed of reporting and tests offered and
46 biases in the sample set are likely, making the dataset unlikely to be representative (score 3).
47

48 6. Retailers: A number of retailers collect health and welfare data alongside performance data from farms
49 supplying pigs to them. They mostly collect data from their supply chain (from farm and/or slaughterhouse
50 records), linking them with reports from BPHS and other schemes, rather than having their own active
51 surveillance systems (data collection score 1). However, specific retailer surveillance schemes related to
52 offal condemnations and visual inspection of carcasses were identified and retailers also inspect producers

1 to ensure they are meeting the agreed standards of production. Parameters specified in the 20:20 Vision,
2 covering lameness, tail biting and tail docking, are collected from inspectors at the abattoir lairage and
3 slaughter line, as well as factors on meat quality, including condemnations. The schemes ensure producers
4 meet the required retailer standards and allows retailers to make management decisions when slaughter
5 pigs are not compliant, such as to prioritise farm investigations. There is no known detailed analysis
6 completed on the health and welfare data and currently no external access to the information (data analysis
7 and communication scores of 3), but the results could be used to examine trends. A weakness of this source
8 is the lack of standardisation between retailers, meaning that the analysis could only be conducted on a
9 subset of the pig population or by assessing each retailer's information in tandem (data completeness score
10 3).

11 Summary of BPEX 20:20 Vision welfare outcome coverage

12 Of the welfare conditions identified by AHDB as being of importance to the pig industry, suitable useful data
13 were only currently available for monitoring tail biting through the BPHS and FSA slaughterhouse schemes.
14 These provide standardised protocols to detect the condition and good coverage of the pig industry, although
15 they are biased towards healthy finisher pigs. Trends in on-farm tail damage assessed in Real Welfare
16 inspections can help monitor the condition but underrepresent the true prevalence. Data on tail biting held by
17 retailers, are likely to replicate information gathered by other schemes.
18

19
20 APHA welfare inspections and the Red Tractor/ Real Welfare schemes could provide useful baseline
21 estimates of the prevalence of tail docking, non-compliances and information on the length of pig tails.
22 Indeed the first Real Welfare report published provides an overall figure for the number of farms tail docking
23 [24]. However, the APHA welfare surveillance would not provide a large enough population each year for
24 monitoring, whereas the other schemes would be useful for monitoring but would be biased towards
25 commercial finisher farms. Lameness detected ante-mortem, recorded by the FSA scheme, provides good
26 coverage of slaughtered pigs. However, the incidence detected at abattoir may indicate problems with
27 transport rather than reflect welfare standards on the farm. Real Welfare scored as excellent for coverage,
28 data collection, completeness and correctness, sensitivity and specificity with all other factors categorised as
29 good. Due to the use of veterinary assessors and standardised procedures, the scheme could be used to
30 provide robust and reliable quarterly monitoring of trends of tail docking and lameness [25-26], which would
31 allow trends to be monitored over time. However, as the scheme does not collect data on lameness in culled
32 pigs, the results may not provide an accurate reflection of prevalence in the full pig population. Lameness
33 incidents may be recorded in PVP reports, but accessing this information in a standardised manner from
34 these is not currently feasible.

35
36 Teeth clipping of piglets was only recorded by the Red Tractor scheme. This could provide quarterly
37 estimates of the use of this practice in assured commercial breeding farms only, as non-assured pig
38 premises with breeding pigs, which includes many small holders and pedigree breeders, are not included.
39 Red Tractor scored highly for coverage and data collection, but issues were raised over completeness and
40 accuracy of the data. During previous assessments of Red Tractor data [27] inconsistencies and missing
41 values in the assessments were highlighted, although recent initiatives to improve these issues meant that
42 these factors were not scored as poor. The recording of categorised proportions of pigs with clipped teeth
43 was introduced relatively recently and so historical data was lacking, although a binary (yes, no) response to
44 teeth clipping had been recorded previously up to 2002.

45
46 Welfare problems related to freedom around farrowing would be included under APHA welfare surveillance,
47 which covers all pig farms. However, the data held electronically would not identify the nature of any non-
48 compliance. The Red Tractor scheme records the use of farrowing crates by member farms but does not
49 record how prevalent it is on a farm or the specifics of the type and size of crate used. The schemes did not
50 provide a suitable dataset for estimating a baseline or for monitoring of freedom around farrowing.
51

1 From our assessments, none of the schemes collected specific details on the husbandry of entire males over
2 80 kg. However, the 20:20 Vision objective does not indicate what parameters are considered relevant and
3 necessary for assessment of this issue. Details of pre- and post-weaning mortality are only collected by PVP
4 in the schemes assessed. The issues relating to PVP data have been outlined above and the provision of
5 estimates would also be hampered by the lack of standardisation in how these mortality measurements are
6 calculated, with some including culled pigs while others do not.

8 Summary of BPEX 20:20 Vision health outcome coverage

9 VIDA provides an accurate source of data for ongoing monitoring of temporal and regional disease trends
10 due to *Brachyspira hyodysenteriae*, PRRSv, *M. hyopneumoniae* and APP. To provide the greatest detail,
11 coverage and representativeness VIDA would need to be complemented by data for these diseases from
12 PVPs or Red Tractor. VIDA data would complement those from Red Tractor as VIDA scored highly for
13 historical data, with the system starting in 1975, but poorly for bias and representativeness. The surveillance
14 is continuous whereas Red Tractor covers a very high proportion of commercial farms, but only assesses the
15 farms every quarter. Red Tractor data would only record whether PRRS or swine dysentery was present and
16 not the severity. VIDA data are currently used for monitoring the diagnostic rate, rather than prevalence of
17 disease, and the relatively low frequency of diagnosis of some of the health conditions may limit the ability to
18 identify significant changes over time. Data held by PHIP would have been limited by the number of holdings
19 sharing that information within the scheme.

20
21 Mange is recorded by VIDA, PVP and PHIP, while BPHS records papular dermatitis as a proxy for mange. It
22 is unlikely that VIDA would provide a useful estimate of mange as it is infrequently recorded. Although
23 identifying herds with a mange problem to provide a baseline or for monitoring could be achieved through
24 PVP and PHIP, issues with standardisation of PVP recording and access to data, and PHIP's lack of
25 coverage and sustainability, would limit their usefulness. The findings of the review suggest that BPHS would
26 provide the best platform for standardised monitoring of mange lesions, although severe cases are unlikely
27 to present at slaughterhouses. A drawback is that smaller herds will be under-represented and these may
28 have a higher incidence of mange than commercial herds, especially now that many commercial herds are
29 free of mange [28].

30
31 The presence of *M. hyopneumoniae* (the causative agent of EP) and APP was recorded by many schemes.
32 The BPHS slaughterhouse scheme can provide a robust estimate of prevalence for monitoring, although this
33 would only represent member farms and healthy finisher pigs. Private laboratory and VIDA disease data
34 would provide large 'on-farm' coverage but submissions would only be likely to be sent when the prevalence
35 amongst the herd increased or became problematic. Analysing these datasets in tandem would provide a
36 more effective monitoring of these conditions. PVP are likely to record EP and APP in the clients' herds but
37 the data are not currently in an accessible or standardised form suitable for analysis. The Red Tractor
38 scheme records farm infection status for *M. hyopneumoniae*, and although this would cover most commercial
39 farms, quarterly updates of these statuses would not be suitable for real-time monitoring and temporal
40 analysis. The FSA slaughterhouse inspections only record pneumonia and so could only provide a basic
41 proxy, whereas PHIP would not have provided countrywide coverage and did not assess APP.

42
43 *Ascaris suum* (which results in milk spot lesions) is recorded by four schemes. PVP data would have the
44 same issues as those described above, while VIDA diagnoses are few and do not provide a robust scheme
45 for monitoring, leaving BPHS and FSA as the most effective sources of information. It is acknowledged that
46 milk spot may be absent when *A. suum* worms are present and vice versa, and milk spot lesions do not
47 always correlate with presence of *A. suum* worms in the intestine.

48
49 The collection of data on post-mortem lesions was recorded by BPHS, FSA slaughter inspections and by
50 retailers. The BPHS scheme would be the best source of these data as the lesions identified in the 20:20
51 Vision were aligned to those within this scheme. The BPHS scheme was scored excellent for coverage,
52 stability, historical data and specificity and good for bias, completeness and correctness, representativeness

1 and sensitivity. However, the assessments are only collected every quarter for each member meaning that
2 analysis could only be used to compare quarters rather than assess true temporal trends. The FSA data may
3 provide greater coverage and timeliness of data collection for the lesion conditions. Concerns over the
4 sensitivity of FSA inspections for the monitoring of conditions and standardisation between assessors
5 indicate that the system, as assessed at this time point, may not currently be as useful as BPHS for this
6 purpose. This has been demonstrated in a study of the correlation of results between the two schemes [29].
7 The retailer data also covered the recording of carcass lesion inspections and would have good coverage
8 from commercial farms but the lack of standardisation between retailers, and potential difficulties with
9 accessing the data, limit the usefulness of the data. Retailer data provided the only source of data for
10 condemned pig meat and analysing the data from the different retailers in tandem may provide a basic
11 monitoring scheme for this factor.

12
13 Antimicrobial usage, as determined by the BPEX 20:20 Vision (mg of active ingredient/ kg of pig), was not
14 recorded by any of the assessed data sources. The most useful proxy for this would be the use of the VMD
15 antimicrobial sales data. However, this figure does not directly reflect use on pig farms and the denominator
16 used (PCU) does not accurately indicate milligrams of active ingredient in kilograms of pig, as the values for
17 a specific antibiotic used on adult sows and piglets would vary greatly. Additionally, from 2013 onwards the
18 VMD report concentrated on reporting antibiotic sales and surveillance of resistance, ceasing reports of
19 sales of other antimicrobials (anti-fungals, coccidiostats etc) although these data are still collected [30].
20 Although pig veterinary practices would record treatments sold and may include details about which pig
21 types were treated, these data would be difficult to extract from each practice in a standardised format to
22 provide suitable coverage. None of the schemes reported data on detection or prevalence of MRSA or
23 *Salmonella* in pig meat.

24 25 **Discussion**

26 Selected data sources were reviewed in a standardised manner for their ability to assist with the production
27 of baseline values and ongoing monitoring for pig health and welfare conditions determined to be of high
28 importance by the BPEX 20:20 Vision. The appraisal of the identified data sources highlighted a range of
29 health and welfare conditions that could be monitored effectively, but the data sources had diverse
30 characteristics influencing their suitability. The coverage and representativeness of the datasets were key,
31 with schemes such as PHIP suffering poor geographical coverage that would limit the ability to monitor
32 geographical trends, whereas schemes that collected data periodically (e.g. BPHS, Red Tractor) would limit
33 analysis of temporal trends within a year. Slaughterhouse schemes were biased towards healthy finisher
34 pigs; VIDA and PVP reports have data from diseased pigs; while other schemes mostly collect data from
35 finisher pigs. These differences highlight the need to analyse multiple datasets in tandem to enhance
36 monitoring. The findings also highlight the scarcity of data sources currently collecting Vision outcomes from
37 breeding pigs. An important concern is the lack of temporal stability and whether they will continue to be
38 funded in their current forms. The lack of historical data present in some schemes also reduces the ability to
39 compare between periods of data. These identified factors suggest that the use of data sources in their
40 current form to determine national prevalence figures would be problematic, whereas monitoring trends
41 within each data source and in tandem with other data sources is likely to be the best approach [29]. This
42 study highlights the value of BPHS and VIDA as sources for data trend analysis from pigs at different stages
43 of their production cycle. However, the continuation of the former is being challenged and there have been
44 substantial changes in the surveillance network from which VIDA data is derived since 2014 [31, 32]. In
45 addition, submissions to private laboratories and VIDA are influenced by multiple factors as described above
46 and reductions in submissions would affect the robustness of surveillance. The description of all of the
47 strengths and weaknesses and collation of background information for each of the schemes would be vital to
48 interpreting the outputs from any analysis.

49
50 The review also highlighted areas where improvements could be made or where additional schemes are
51 required. No suitable sources were found for husbandry of entire males over 80 kgs, pre and post weaning
52 mortality, condemned pig meat, antimicrobial usage, mange, MRSA and *Salmonella* in pig meat. The launch

1 of the electronic Medicines Book for pigs in April 2016 has enabled collection of antimicrobial usage data
2 direct from pig farms into the AHDB pig-hub. The requirement to enter data on a quarterly basis as part of
3 Red Tractor standards, since October 2017, has provided good coverage of antimicrobial usage in the pig
4 sector [33, 34]. It is now possible to make comparisons between farms, in the form of benchmarking. As
5 more years of data are collected then robust trend analysis may be achievable, dependent on the quality of
6 the data entered.

7
8 The review highlights that several surveillance gaps identified could be solved by access to PVP data, if it
9 was appropriately standardised. Additionally, the development of a methodology to collect pig disease
10 incident data from practitioners, via a mobile app, was a recommendation from a recent meeting of
11 Government, pig industry and veterinary stakeholders to discuss syndromic surveillance in pigs [35]. Access
12 to data from private laboratories would also complement the data held in VIDA and provide wider coverage
13 for certain pathogens. However, gaining access to data from commercial entities like private laboratories
14 may be problematic as shown by a previous study [36]. This was due to the commercially sensitive nature of
15 the data plus an unwillingness to standardise data collection and recording, especially where this would not
16 meet a business need. General threats to the use of these private schemes include: the increasing
17 recognition that data have a commercial value whilst funding for disease monitoring is reducing; restrictive
18 access; and limited data checking/ cleaning to ensure data quality is maintained in these schemes. Future
19 initiatives may require incentives such as regular feedback of data for their clients or access to expertise
20 (such as statistical analysis), which might improve data sharing. Methods have been developed for other
21 purposes, such as SAVSNET by Liverpool University [37] and VetCompass designed by the Royal
22 Veterinary College (<https://www.rvc.ac.uk/vetcompass>). These systems allow data to be collected directly
23 from small animal vet practices and diagnostic laboratories for use in data analyses which could be amended
24 and customised to meet the needs of livestock surveillance. The development of any similar system for
25 livestock surveillance will face a number of fundamental challenges. Not the least of which will be the
26 different nature of the records currently kept for livestock, which is more often focussed on business matters,
27 such as invoicing and billing, rather than electronic health record keeping. Any such development will also
28 require significant funding.

29
30 The data sources reported here and others in action can potentially provide estimates for other health and
31 welfare conditions than they were originally designed. There are also further opportunities to develop the
32 datasets for harmonisation or improved data collection. Ongoing Government surveillance schemes for
33 Aujeszky's Disease and Trichinella could extend the coverage of the breeding pig population for monitoring
34 schemes and could be used as a cost-efficient method for collection of samples to be tested for some of the
35 Vision conditions that are not covered suitably elsewhere (such as *Salmonella* in pig meat or MRSA). Recent
36 data sources, such as Real Welfare, also have the potential for monitoring trends if the schemes are
37 sustained and are able to cover a representative population. Data on condemned pig meat could be
38 collected direct from each slaughterhouse as this is referenced to each farm to deduct from the price paid to
39 each producer. Improving the accuracy of welfare data in these areas will allow useful analyses, such as
40 quantifying and determining association between, for example, tail docking, tail biting and other outcomes.
41 These analyses could lead to more evidence-based health and welfare decisions.

42
43 The evidence indicated that the SERVVAL framework provided an effective template for surveillance scheme
44 comparison and evaluation for specific conditions but a full description of any scheme requires detailed
45 knowledge of how it works in reality. The ability to select from a panel of attributes allowed for the key factors
46 for surveillance to be assessed efficiently without the need to cover every aspect of the schemes. Although
47 the scoring of each attribute was limited to just three options, this made the evaluations simpler while still
48 making it easy to identify the strengths and gaps of each scheme. Surveillance evaluations require a
49 standardised approach, and a defined objective, and the SERVVAL framework ensures the scores were easy
50 to compare across schemes while more detailed relevant details could be recorded elsewhere in the
51 evaluation.

52

1 This review has provided a useful, standardised assessment of the ability to monitor health and welfare
2 conditions that are important to the pig industry. The findings could be used to help coordinate and provide a
3 framework for the collation and analysis of data from these schemes, and highlights areas of improvements
4 that are required; priority being development of syndromic surveillance (collection of clinical disease incident
5 data) and data from private laboratories testing samples from pigs. Updates to this review, using the same
6 method to assess new data sources would be useful to track developments and encourage progress.
7 Additionally, reviews of similar schemes from other livestock industries would also be beneficial, especially
8 as synergies may be found.

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