REFERENCES


FURTHER PUBLICATIONS OF INTEREST


http://dx.doi.org/10.1371/journal.pone.0135010.


http://dx.doi.org/10.1093/jac/dku098.

http://dx.doi.org/10.1080/00071668.2014.955081.


enhance antibody-based immune responses to Salmonella typhimurium infection in pigs. Animal Feed Science and Technology 201, pp. 57-65.


Quality Statement

SECTION A

1. Coherence
Reports are obtained by various routes: direct submissions to APHA Veterinary Investigation Centres, reports of *Salmonella* isolations by private laboratories and Scottish submissions to Scotland’s Rural College (SRUC).

APHA is responsible for collation of data. Submissions result from cases of clinical disease in livestock, monitoring of healthy livestock and investigations of possible links with a human *Salmonella* outbreak.

All private laboratories submitting reports of *Salmonella* isolates to APHA do so using the standard APHA submission & supplementary forms or customised forms developed for them by APHA. Scottish submissions use the SRUC submission form & supplementary forms which are compatible with the APHA system and interpreted in the same way. All use the same definitions and essential categorisation.

An incident comprises the first isolation and all subsequent isolations of the same serovar or serovar and phage/definitive type combination of *Salmonella* from an animal, group of animals or their environment on a single premises, within a defined time period (usually 30 days).

An antimicrobial susceptibility test is performed for surveillance purposes against an extended panel of 16 antimicrobials on *Salmonella* isolates sent for serotyping to APHA Weybridge and APHA Lasswade.

<table>
<thead>
<tr>
<th>Antimicrobial</th>
<th>Concentration (µg per ml)</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Nalidixic acid</td>
<td>30</td>
<td>NA</td>
</tr>
<tr>
<td>2 Tetracycline</td>
<td>10</td>
<td>T</td>
</tr>
<tr>
<td>3 Neomycin</td>
<td>10</td>
<td>N</td>
</tr>
<tr>
<td>4 Ampicillin</td>
<td>10</td>
<td>AM</td>
</tr>
<tr>
<td>5 Furazolidone</td>
<td>15</td>
<td>FR</td>
</tr>
<tr>
<td>6 Ceftazidime</td>
<td>30</td>
<td>CAZ</td>
</tr>
<tr>
<td>7 Sulphamethoxazole/trimethoprim</td>
<td>25</td>
<td>TM</td>
</tr>
<tr>
<td>8 Chloramphenicol</td>
<td>30</td>
<td>C</td>
</tr>
<tr>
<td>9 Amikacin</td>
<td>30</td>
<td>AK</td>
</tr>
<tr>
<td>10 Amoxicillin/ clavulanic acid</td>
<td>30</td>
<td>AMC</td>
</tr>
<tr>
<td>11 Gentamicin</td>
<td>10</td>
<td>CN</td>
</tr>
<tr>
<td>12 Streptomycin</td>
<td>10</td>
<td>S</td>
</tr>
<tr>
<td>13 Sulphonamide compounds</td>
<td>300</td>
<td>SU</td>
</tr>
</tbody>
</table>
This panel is updated when there is a clear need to detect new or emergent types of resistance or to replace outdated antimicrobials. On specific occasions (e.g. detection of *Salmonella* vaccine strains, characterisation of 3rd generation cephalosporins resistance) more than 16 antimicrobials are used for susceptibility testing.

From 1st January 2007, some of the breakpoints used in assessing antimicrobial resistance, which were previously set at less than or equal to 13mm, were changed. These new breakpoints were set at: Ceftazidime (CAZ) less than or equal to 27mm, Amikacin (AK) less than or equal to 18mm, Ciprofloxacin (CIP) less than or equal to 19mm and Cefotaxime (CTX) less than or equal to 29mm. This may result in an increased number of isolates resistant to these antimicrobials in 2007 and the subsequent years in comparison with previous years. The breakpoint for all other antimicrobials used remains at less than or equal to 13mm.

In 2008, the disc concentrations for streptomycin and chloramphenicol were changed to adopt the disc concentrations recommended by the British Society for Antimicrobial Chemotherapy (BSAC). In the case of streptomycin, the disc concentration was reduced from 25µg to 10µg. The zone size remained unchanged, so this change would be expected to increase the detection of isolates with lower level streptomycin resistance. Work done at APHA has shown that the 10µg disc provides much better discrimination between resistant and sensitive isolates (defined using the gold standard measure of MIC determination) than the 25µg disc.

The only other change made to the breakpoints and disc concentrations used over the period 2008-2015 related to the ceftazidime disc where the zone size was reduced from 29 to 26mm in 2012, in line with BSAC recommendations.

Some of the *Salmonella* serovars are recorded and reported in APHA under the old nomenclature. The nomenclature for these serovars under the original Kauffmann-White scheme is clarified in the table below:

<table>
<thead>
<tr>
<th>Code</th>
<th>Antimicrobial</th>
<th>Concentration (µg per ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTX</td>
<td>Cefotaxime</td>
<td>30</td>
</tr>
<tr>
<td>APR</td>
<td>Apramicin</td>
<td>15</td>
</tr>
<tr>
<td>CIP</td>
<td>Ciprofloxacin</td>
<td>1</td>
</tr>
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</table>
APHA Serovar | White-Kauffmann-Le Minor Serovar
--- | ---
Pullorum | Gallinarum (biovar Pullorum)
Java | Paratyphi B var. Java
Newington | Anatum var. 15

The *Salmonella* serovars *S*. Binza and *S*. Thomasville, which were previously recorded by the APHA under their old nomenclature, are now recorded using the White-Kauffmann-Le Minor notation as *Salmonella* Orion var. 15 and *Salmonella* Orion var. 15 34 respectively. This change was implemented during 2008.

2. Accuracy and precision

**Sampling error:** Isolations of *Salmonella* from statutory species are required to be reported, however the level of detection and testing (for species without a NCP) depends on submission of samples for laboratory investigation by private vets as well as on economic and other factors e.g. distance to laboratories etc.

A susceptibility test is often performed on representative *Salmonella* isolates before the allocation of an automatic incident reference by the computer system. It is important for the Veterinary Investigation Centres to provide information to the testing laboratory on whether the submitted isolates are considered to comprise new incidents. As some companies perform extensive testing for *Salmonella*, this could skew the overall antimicrobial resistance data leading to the patterns obtained, at least in part, reflecting the intensity of sampling procedure. Also, limited resources may prevent susceptibility testing of all isolates.

**Coverage error:** The reasons for sample submissions (particularly for non-NCP samples) need to be considered, as sources of error can be dependent on this factor. Also the ability to isolate *Salmonella* needs to be considered (dependent on sample type taken, age of sample, storage and transport, culture method used, laboratory staff technical expertise etc).

**Non-response error:** Although all *Salmonella* isolations from statutory species are required to be reported, not all data items requested are mandatory under the Zoonoses Order. Different categories of submissions may have different non-response rates for different data items.

**Measurement error:** Different *Salmonella* culture methods vary in their sensitivity, which varies according to sample type, type of *Salmonella* present and profile of competitive flora in the sample. Data on the APHA and SRUC forms are subject to individual interpretation by the person
submitting the information, despite the guidance to authorised personnel.

The requirement of this report is to include as much data as is available. However only approved submissions are included, although efforts are made to ensure that all submissions are approved before the data is extracted. Data are scrutinised to correct errors in results for strategically important isolates (e.g. resistant to 3rd generation cephalosporins, resistant to ACSSuT pattern). It is not expected to routinely see resistance to amikacin, ciprofloxacin, ceftazidime or cefotaxime in any isolate. If any appears, it is followed up at the time of detection and the isolate would normally be re-tested.

Both laboratories at APHA Lasswade and APHA Weybridge that perform the expanded susceptibility testing have third party accreditation to ISO17025 provided by UKAS.

Data processing error: It is often difficult to obtain the required information from the sample submitted for non-mandatory data. It is the responsibility of the Nominated Officer to ensure that the data are accurate and complete. A validation exercise is carried out on a weekly basis at the APHA Veterinary Investigation Centres and by DoES, and on a quarterly basis for NCP submissions.

As a result of refinements to the method of defining incidents, it may not always be possible to reproduce isolation figures in previously published reports.

3. Timeliness and punctuality
The report includes provisional data (with the exception of the flock-level data for the chicken and turkey NCPs) which are subject to change. The APHA Salmonella warehouse is updated every night.

4. Accessibility and clarity
Salmonella data (APHA) have a related metadata profile (see section B).

5. Comparability
Salmonella cases in animals are reported both as isolations and incidents. An incident is defined as the first and all subsequent isolations of the same serovar or serovar and phage type combination of a particular Salmonella from an animal, group of animals or their environment on a holding within a defined time period, which is usually
30 days. An incident report is a herd/ flock (which is the epidemiological group of interest) level outcome.

Changes in the number of *Salmonella* isolations from poultry and pigs over time may reflect changes in the monitoring activity conducted by the livestock industry and not necessarily changes in incidence in *Salmonella* infection. The number of tests carried out by authorised laboratories is collated by Defra.

Sampling error, coverage error and measurement error is minimised for submissions from NCP samples as they follow a robust, harmonised protocol and test method.

Chicken and turkey data are not directly comparable before and after implementation of the NCPs. For example, before 2010 the turkey NCP was not in operation so all turkey submissions were voluntary whereas from the beginning of 2010, most turkey submissions were from statutory monitoring. Comparisons are more valid for years in which the NCPs have run for a full year previously.

The data on positive findings of *Salmonella* in laying, breeding and broiler chicken flocks, and in turkey flocks is reported as the number of positive flocks, as required by the legislation, as well as the number of positive isolations detected during the year. The number of reported isolations of *Salmonella* detected in chickens and turkeys does not equate directly to the overall number of positive flocks that are detected during the year. A flock is counted as positive only once, irrespective of the number of isolations occurring and the number of serovars identified.

**Hatchery isolations not associated with a specific flock.** Starting with samples collected from 1st January 2006, any hatchery isolates where there are no supply flock details available are treated as isolations only and not incidents as they cannot be traced back to a specific flock.

**SRUC and other isolations/reports without cultures submitted.** Submissions received from the Scotland’s Rural College (SRUC), and any submissions received without a sample are now allocated an incident reference whereas previously these were not allocated such references. These reports appear in the quarterly reports. This improvement was put in place for all reports on the database in 2008.

Not all isolates of *S. Typhimurium* from bovine animals received from SRUC are phage typed. As the system does not allocate an incident reference number to a report of *S. Typhimurium* until the phage type
result is received, this means that some isolates of S. Typhimurium from SRUC will not be allocated an incident reference and therefore the actual number of incidents of S. Typhimurium may be higher than the number recorded on the database.

**APHA Quality Assurance Statement**

The policy of the Animal and Plant Health Agency (APHA) is to maintain a high standard of quality in all aspects of its operation and to continually satisfy our customers in respect of all the services offered.

The laboratory facilities are UKAS accredited to BS EN ISO 17025:2000 (Lab Nos. 0941, 1769 and 2112) for an extensive range of tests supported by proficiency testing accredited to ISO/IEC Guide 43-1 1997 (Lab No. 0004). APHA is certificated to BS EN ISO 9001:2000 for ‘the provision of a range of specialist veterinary scientific services to the Government and other interested parties worldwide’ (Certificate Nos. LRQ 4000436, 4001071, 0962413 and 4001392).

Additionally, APHA holds Good Laboratory Practice and Good Manufacturing Practice approval and complies with the Joint Code of Practice for Research projects and Good Clinical Veterinary Practice quality standards.

APHA Weybridge is accredited to BS EN ISO 14001:2004 for environmental management system.
### SECTION B

#### METADATA ELEMENTS

<table>
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<th>Metadata elements</th>
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## ADDITIONAL REPORT METADATA ELEMENTS

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Acknowledgements

Isolations were reported by Nominated Officers of the Animal and Plant Health Agency for England and Wales and Divisional Veterinary Managers for Scotland and, through them, by private laboratories.

Regional Veterinary Leads of the Animal and Plant Health Agency are responsible for the collection of samples of processed animal protein.

Staff of the Animal and Plant Health Agency processed the data.

The following reference laboratories made or confirmed the majority of isolations:

- PHE Laboratory of Enteric Pathogens, Colindale.
- Scottish *Salmonella* Reference Laboratory, Glasgow.

This report was compiled by:

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APHA is an Executive Agency of the Department for Environment, Food and Rural Affairs and was formed on 1st October 2014. Prior to this it was known as AHVLA.