Antimicrobial resistance: harmonisation of national antimicrobial resistance monitoring and surveillance programmes in animals and in animal-derived food

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This report, prepared by the OIE Ad hoc Group of experts on antimicrobial resistance, has not yet received the approval of the International Committee of the OIE

Summary
A guideline on the harmonisation of national antimicrobial resistance monitoring and surveillance programmes in animals and animal-derived foods has been developed by the Ad hoc Group of experts on antimicrobial resistance of the Office International des Epizooties. The objective of the guideline is to allow the generation of comparable data from various national surveillance and monitoring systems in order to compare the situations in different regions or countries and to consolidate results at the national, regional and international level. Definitions of surveillance and monitoring are provided. National systems should be able to detect the emergence of resistance, and to determine the prevalence of resistant bacteria. The resulting data should be used in the assessment of risks to public health and should contribute to the establishment of a risk management policy. Specific factors identified for harmonisation include the animal species, food...
Introduction

This document describes the objectives of programmes for the monitoring and surveillance of antimicrobial resistance in bacteria of animal origin and animal-derived food products. The programmes will serve as a basis for the detection of national and global trends in the development of antimicrobial resistance in these bacteria. Animal species, food products, bacterial species and antimicrobials to be included in the programmes will be proposed. Sampling strategies, including statistically-based sampling options, data collection, recording, evaluation, and access to the data are considered. Comments are made on programme costs that may be of relevance to Member Countries.

All aspects relating to laboratory methodologies are dealt with in Antimicrobial resistance: standardisation and harmonisation of laboratory methodologies for the detection and quantification of antimicrobial resistance, earlier in this volume.

Background

Antimicrobial susceptibility testing of bacteria has basically aided the clinician in the choice of efficient antimicrobials. Numerous point prevalence studies on antimicrobial resistance in bacteria of animal origin have been reported. Unfortunately, the usefulness of data from published studies is often hampered by inadequacies in study design. The methods and interpretive criteria used vary and comments on drug statistics are rarely included. The number of investigated isolates is generally low and confidence limits are rarely presented. The inclusion and exclusion criteria for the isolates included may be reasonably well described, but not the criteria for sampling. For example, most studies include results from clinical specimens sent to laboratories for routine analysis. It should be borne in mind when designing resistance monitoring and surveillance programmes that results from diagnostic submissions may not reflect the resistance situation in the animal population, as these types of submissions tend to include specimens from severe and/or recurrent clinical cases, including therapy failures. As a first step towards comparability of monitoring and surveillance data, Member Countries of the Office International des Epizooties (OIE) should be encouraged to strive for harmonised and standardised programme design (2, 15, 17, 20). Data from countries using different methods and study design may otherwise not be directly comparable (10, 20). Nevertheless, data collected over time in a given country may at least allow the detection of emergence of antimicrobial resistance or trends in prevalence of resistance in that particular country.

A limited number of countries has established national structures for central collection and evaluation of antimicrobial susceptibility data of bacteria isolated from animals (1). In most countries which have already initiated official resistance monitoring and surveillance, these programmes arose from the need to give guidance to practitioners on appropriate clinical therapy. Recently in some countries, programmes have been extended to include knowledge about antimicrobial resistance in food-borne pathogens and commensal bacteria, including evaluating local, regional and national trends (4, 7, 12, 13, 22). Existing systems may include central co-ordination, harmonisation of laboratory methodology, establishment of quality assurance schemes and external proficiency testing by a designated national co-ordinating laboratory.

Definition of monitoring and surveillance

In the International Animal Health Code, the OIE defines surveillance in animal health as ‘the continuous investigation of a given population to detect the occurrence of disease for control purposes, which may involve testing of a part of the population’. According to the OIE definition, monitoring ‘constitutes on-going programmes directed at the detection of changes in the prevalence of disease in a given population and in its environment’ (16).

In the context of this guideline, ‘disease’ can be substituted by ‘antimicrobial resistance’.

The chapter of the International Animal Health Code on monitoring and surveillance of animal health describes options for agent detection and disease prevalence. Antimicrobial resistance and prevalence can follow some of the OIE commodities, sampling plans, bacterial species, antimicrobials to be tested, laboratory methods, data reporting, database structure and the structure of reports.

Keywords
monitoring and surveillance definitions in animal disease guidelines mentioned below:

a) scientifically-based surveys (including statistically-based programmes)
b) routine sampling and testing of animals on the farm, at market or at slaughter
c) an organised sentinel programme, sampling animals, herds, flocks, vectors, and/or collecting diagnostic results from veterinary practice
d) the storage of biological specimens for retrospective studies
e) analysis of veterinary diagnostic laboratory records.

Passive surveillance is conducted when samples are submitted to a laboratory for testing by sources outside the programme. Active surveillance is conducted when the programme develops a sampling scheme based on the objectives of the programme and actively obtains isolates.

Reasons for resistance monitoring and surveillance programmes

Resistance monitoring and surveillance programmes are intended to generate data that can be used as follows:

– in risk analysis to determine risk to human and animal health
– to detect emergence of antimicrobial resistance (e.g. particular phenotypes)
– to determine the prevalence or trend in prevalence of reduced susceptibility to a certain antimicrobial (or resistance) in a defined population
– to provide a basis for policy recommendations for animal and public health
– to generate data that may guide the design of further studies
– to identify the need for potential interventions
– to assess the impact of interventions
– to provide information for prescribing practices and prudent use recommendations.

General aspects to be considered in resistance monitoring and surveillance

When Member Countries are considering their options for the control of antimicrobial resistance arising from the use of antimicrobials in animals, several issues should be examined and analysed. In particular, the resistance situation in humans, including resistance in bacteria of concern to human medicine, and the capacity of countries to undertake resistance surveillance in bacteria of human origin should be taken into consideration. Monitoring of bacteria from animal-derived food collected at different steps of the food chain, including processing, packing and retailing, should also be considered.

There are large variations among Member Countries both in the extent of the use of antimicrobials in animals and the public concern over such use. However, for all countries, the basic mechanisms of exposure of humans to resistant bacteria from food are the same. Exposure of humans to resistant bacteria can be either direct through exposure to zoonotic pathogens (Salmonella, Campylobacter), or indirect through exposure to resistance genes potentially transferable from commensal animal bacteria, such as Escherichia coli and Enterococcus spp., to human bacteria (9, 18, 21).

Any antimicrobial use will exert selection pressure on exposed bacteria and may result in development of resistance. This should be taken into account when designing monitoring and surveillance programmes. This means that information is required on the antimicrobial substance used, the mode of usage and the quantities used. Although there is no linear relationship between the amount of a certain antimicrobial used and the development of resistance, increased use of an antimicrobial often results in decreased susceptibility among exposed bacteria. An antimicrobial selective pressure may affect the resistance phenotype of bacteria in different ways, as follows:

a) cross-resistance and co-selection of resistance genes may explain how one antimicrobial selects for another antimicrobial
b) multiple resistance confers resistance to several antimicrobials
c) virulence and lack of hygiene may account for the survival and spread of resistant bacteria, even in the absence of an antimicrobial selection pressure (14).

Thus, the rate of development of resistance in bacteria will, amongst others, depend on the character(s) of the resistance gene(s), such as transferability, time of exposure of the microorganism to the antimicrobial, and not least on the characteristics of the exposed bacterial populations (11).

Surveillance of antimicrobial resistance at regular intervals or ongoing monitoring of prevalence changes of resistance bacteria of animal, food, environmental and human origin, constitutes a critical part of a strategy aiming at limiting the spread of antimicrobial resistance and optimising choice of antimicrobials used in therapy. As the situation will vary over time and between countries and regions, data need to be collected at the appropriate regional and national level.
Monitoring and surveillance programmes may serve as early warning systems in the sense that even minor shifts in susceptibility may be identified at an early stage. Interventions may then be taken to limit the further shifts in susceptibility or spread of resistance.

Despite differences among Member Countries, it is essential that countries consider the collection of certain standardised information and the harmonisation of their surveillance and monitoring programmes to enable the international comparison of data. As bacteria do not respect country boundaries, the ability to evaluate the situation at a global level will enable a better assessment of the potential risks posed by resistant bacteria on human and animal health. The risk for human health from resistant bacteria or resistance genes of animal origin should, as far as possible, be quantified and put into perspective with other human health risks. As recommendations prepared by the OIE will be of global relevance, careful consideration must be given to realistic needs and public and animal health issues of OIE Member Countries in all regions of the world.

**Specific factors to be considered for the harmonisation of resistance monitoring and surveillance programmes**

To achieve comparability of results between national monitoring and antimicrobial surveillance programmes, the following factors should be considered by Member Countries in the design of such programmes:

a) animal species/categories (including age) to be sampled

b) for food sampling, the relative merits of sampling at the abattoir and retail outlet should be considered. In addition to food of domestic origin, food of foreign origin may also be considered, possibly at the port of entry of the products

c) sampling strategy to be employed, for example: active or passive collection of samples; random, stratified or systematically collected samples; statistically based sampling or opportunistic sampling

d) samples to be collected (faeces, carcass, raw and/or processed food)

e) bacterial species to be isolated

f) antimicrobials to be used in susceptibility testing

g) standardised susceptibility testing (under laboratory methodologies)

h) quality control – quality assurance (under laboratory methodologies)

i) type of quantitative data to be reported (under laboratory methodologies)

j) database design for appropriate data extraction

k) analysis and interpretation of data

l) reporting (consideration of transparency of reporting and interests of stakeholders).

A detailed consideration of specific factors is presented below.

**Animals**

Each Member Country should examine its livestock production systems and decide, after risk analysis, the relative importance of antimicrobial resistance for animal and human health. Categories of livestock that should be considered for sampling include cattle and calves, slaughter pigs, broiler chickens, layer hens and/or other poultry and farmed fish. The results of this examination coupled with knowledge of antimicrobial use in animals, where available (see *Antimicrobial resistance: monitoring the quantities of antimicrobials used in animal husbandry*, earlier in this volume), regional and seasonal factors, as well as the international trading status of the Member Country (e.g. net importer or exporter of livestock products), may influence the design of resistance monitoring and surveillance programmes.

**Food**

When considering the transfer of antimicrobial resistance from animals to humans, contaminated food is commonly considered to be the principal route. Antimicrobial resistance can be transferred either by pathogenic bacteria or by transfer of resistance genes carried by commensal bacteria.

Raw food of animal origin may be contaminated with resistant enteric pathogens such as *Salmonella* spp., *Campylobacter jejuni* and *Campylobacter coli* or resistant commensal bacteria such as *E. coli* and *Enterococcus* spp. Little is known about the prevalence of resistant bacteria in food of animal origin, but it is important that food bacterial isolates (including isolates from food of plant origin) are included in national monitoring and surveillance programmes for antimicrobial resistance (3, 20). Plants and vegetables of different types may be exposed to manure or sewage from livestock and may thereby become contaminated with resistant bacteria of animal origin. Animal feed, including imported feed, may also be considered in monitoring in surveillance programmes.

**Sampling strategies**

**General**

As described in Chapter 1.3.5. of the OIE *International Animal Health Code* on surveillance and monitoring of animal health (16), Member Countries will have to consider whether to utilise
passively collected data from existing sources of information, such as data from veterinary diagnostic laboratories (appreciating the limitations of the data) and/or design new monitoring or surveillance programmes for specific needs, or perhaps modify existing programmes. After deciding on the objectives of the required programme, for example monitoring antimicrobial resistance prevalence changes in bacterial populations of the national pig herd, specific programme design decisions must be taken.

The OIE recommends that Member Countries, very early in their consideration of the issue, examine their capacity to undertake such work with regards to financial and human resources. Some Member Countries may need to develop basic scientific antimicrobial resistance expertise in the animal health area before embarking on a resistance monitoring and/or surveillance programme. Other countries may have already implemented comprehensive monitoring and surveillance programmes and may only have to consider the issues related to harmonisation as discussed in this paper.

Statistically based sampling strategies for food-borne pathogens and commensal bacteria

Sampling strategies are usually based on two basic features: sample representativeness of the population of interest and the robustness of the sample collected.

Sampling strategies should be based on addressing the defined objectives of the programme.

Samples are typically targeted at representing a specific group or population of interest and may be collected randomly, systematically or stratified within the population of concern. An appropriate sampling strategy provides sample estimates that are accurate for the population of interest. If appropriate sampling strategies have been defined, calculating a statistically based sample size allows programme monitors to determine the precision of the prevalence estimates that will be obtained from the collected sample. Sample size considerations are important, as an inadequate sample size may fail to detect existing resistance and an excessively large sample size is a waste of resources.

The source of sample specimens should be determined by the objectives of the monitoring programme. If the objective is to monitor the potential human health impact of antimicrobial resistant bacteria from food of animal origin, then faecal samples from an appropriate sample source, such as the abattoir, may be the most convenient and least costly option for sample collection (2, 4, 13, 15). This would reflect the prevalence of resistance at the first step of the food chain. Sampling of the carcasses at the abattoir would provide information on slaughter practices, slaughter hygiene and the level of faecal contamination of meat during the slaughter process. Further sampling from the retail chain would provide an indication of prevalence changes before the food reaches the consumer (4, 19). However, for studies on the relationship between use of antimicrobials and prevalence of resistance in animal bacterial populations, samples taken from animals with known health status and antimicrobial exposure might be more suitable (Table I).

Programmes need to be statistically-based, using random sampling techniques, and need to be stratified for relevant factors. An example of a table and formula to assist Member Countries in programme design considerations is included in Appendix A. The sampling should be stratified by geographic region and run continuously over the year to account for regional and seasonal variations. Depending on, amongst others, the financial resources of a country, sampling may be extended over longer time periods or modified in other ways.

<table>
<thead>
<tr>
<th>Source</th>
<th>Sample type</th>
<th>Outcome</th>
<th>Additional information required/additional stratification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herd of origin</td>
<td>Faecal</td>
<td>Prevalence in bacteria originating from animal populations of different age categories and production types</td>
<td>Per age categories, production types, etc</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relationship resistance – antibiotic use</td>
<td></td>
</tr>
<tr>
<td>Abattoir</td>
<td>Faecal</td>
<td>Prevalence in bacterial populations originating from animals at age of slaughter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intestine</td>
<td>As above</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Carcass</td>
<td>Hygiene, contamination during slaughter</td>
<td></td>
</tr>
<tr>
<td>Processing, packing</td>
<td>Meat products</td>
<td>Hygiene, contamination during processing and handling</td>
<td></td>
</tr>
<tr>
<td>Retail</td>
<td>Meat products</td>
<td>Prevalence of resistance in bacteria originating from food, exposure data for consumers</td>
<td></td>
</tr>
<tr>
<td>Various origin</td>
<td>Vegetables</td>
<td>Prevalence of resistance in bacteria originating from vegetables, exposure data for consumers</td>
<td></td>
</tr>
<tr>
<td>Various origin</td>
<td>Animal feed</td>
<td>Prevalence of resistance in bacteria originating from animal feed, exposure data for animals</td>
<td></td>
</tr>
</tbody>
</table>
As different practices for rearing an animal species might entail different antimicrobial exposure, the category of animal included should be strictly defined. If several categories of the same animal species are included, the sampling should again be stratified for these categories. A single animal should be sampled per herd or flock on each occasion. It is the prevalence of resistance and trends in the bacterial populations, rather than the specific prevalence on the herd or flock level, that is of interest in antimicrobial resistance monitoring and surveillance programmes (2, 4).

Bacterial isolates collected in this way will represent a stratified random sample of the bacterial population of each animal species surveyed.

Determining the number of isolates to be tested in order to obtain a statistically robust estimate involves gathering information on the expected prevalence of resistance in the population. The level of precision desired in the prevalence estimate and the degree of confidence that the prevalence estimate would fall within this range are parts of the design parameters of the monitoring or surveillance programme.

The total number of samples required to achieve the targeted number of resistant isolates, with the desired confidence in the estimated prevalence level of resistance, should be based on the statistical considerations mentioned above. Additionally, the known frequency with which bacteria may be isolated from animals or food must be taken into account. Furthermore, the actual number of isolates to be tested may need to be adjusted, due to laboratory and other pragmatic resource considerations. However, in the interpretation of data, the concomitant limitations arising from these adjustments must be recognised and taken into consideration. If results of the monitoring programme indicated a prevalence other than that estimated, the programme testing regime would need to be adjusted, or more detailed surveillance and investigation would be required.

**Sample specimens to be collected (faeces, carcass and retail food)**

As a rule, faecal samples are collected from livestock and whole caeca are collected from poultry. From cattle and pigs, a faecal sample size of 5 g to 50 g will provide a sufficient sample for isolation of the bacteria of concern. A large sample size will result in a higher number of isolates of the target bacterial species compared to a smaller sample size. The same sample can be used for isolation of both zoonotic and commensal bacteria.

Existing food processing microbiological monitoring and ‘hazard analysis and critical control points’ (HACCP) programmes may provide useful samples for monitoring and surveillance of resistance in the food chain after slaughter. However, experience in the collection of this type of sample is currently rare.

**Bacteria**

Three major categories of organisms would be monitored, as follows:

a) animal bacterial pathogens

b) zoonotic bacteria

c) commensal bacteria.

If possible, isolates should be preserved at least until reporting is completed. A collection for retrospective studies may be set up by further storing of all isolates from certain years. Isolates should preferably be stored cryogenically.

**Animal bacterial pathogens**

Monitoring of resistance in animal pathogens is important, both to detect emerging resistance that may pose a concern for human and animal health and to guide veterinarians in their prescribing decisions. Furthermore, this information will be of value in providing guidance for the prudent use of antimicrobials in veterinary medicine. Animal pathogens have the capacity to rapidly spread between animals and may, in consequence, be repeatedly exposed to antimicrobials. Emergence of new resistance mechanisms and loss of susceptibility in animal bacterial pathogen populations will be detected at its earliest stage by surveillance and monitoring programmes for resistance in these bacterial populations. Furthermore, this type of information is readily available in many countries. Information on the occurrence of antimicrobial resistance in animal pathogens is in general derived from routine clinical material sent to veterinary diagnostic laboratories.

These samples are often derived from severe or recurrent clinical cases, including therapy failures. However, because these isolates are likely to represent biased samples, this type of susceptibility data may not show the true prevalence of resistance within the given animal population and the appropriate caution must be exercised in the interpretation of the data. A means of mitigating this bias would be to consider collection of samples from primary clinical cases not previously treated with antibiotics, or isolation of potentially pathogenic bacteria from healthy animals.

**Examples of animal pathogenic bacteria**

The range of priority animal bacterial pathogens to be monitored should be determined, taking into account the national animal health situation.

Examples of bacterial pathogens which may be considered for inclusion in resistance surveillance or monitoring programmes are presented in Table II.
All bacteria should be identified according to internationally recognised standard procedures. Antimicrobial susceptibility testing should be performed with validated methods under internal and external quality assurance (see Antimicrobial resistance: standardisation and harmonisation of laboratory methodologies for the detection and quantification of antimicrobial resistance). It should be noted that there are no validated methods for susceptibility testing of Campylobacter and no internationally accepted reference strains available for quality control. However, work is currently in progress on validation of methods for susceptibility testing of Campylobacter.

**Zoonotic bacteria**

**Salmonella**

Sampling should preferably represent the primary production of cattle, pigs, broilers and other poultry. For the purpose of facilitating sampling and reducing the concurrent costs, samples are preferably taken at the abattoir. However, monitoring and surveillance programmes may also be able to use bacterial isolates from designated national laboratories originating from other sources. A collection of an optimal number of Salmonella isolates should be attempted within the practical and economic constraints of the country. Isolation and identification of bacteria and bacterial strains should follow internationally accepted procedures. Serovars of epidemiological importance such as S. Typhimurium and S. Enteritidis should be included. The selection of other relevant serovars will depend on the epidemiological situation in each country. All Salmonella isolates should be serotyped when appropriate, phage-typed according to standard methods used at the nationally designated laboratories. Validated methods should be used for antimicrobial susceptibility testing of Salmonella (see Antimicrobial resistance: standardisation and harmonisation of laboratory methodologies for the detection and quantification of antimicrobial resistance).

**Campylobacter**

Campylobacter jejuni and C. coli can be isolated from the same samples as commensal bacteria. Isolation and identification of these bacteria should follow internationally accepted procedures. Campylobacter isolates should be identified, but also if possible, typed and characterised. However, this is likely to depend on the technical abilities and resources available in the Member Country.

Agar or broth micro-dilution methods are recommended for susceptibility testing of Campylobacter. Internal and external quality control programmes should be strictly adhered to (see Antimicrobial resistance: standardisation and harmonisation of laboratory methodologies for the detection and quantification of antimicrobial resistance).

**Table II**

Examples of animal bacterial pathogens which may be included in resistance surveillance and monitoring

<table>
<thead>
<tr>
<th>Target animals</th>
<th>Respiratory pathogens</th>
<th>Enteric pathogens</th>
<th>Udder pathogens</th>
<th>Other pathogens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>Pasteurella spp.</td>
<td>Escherichia coli</td>
<td>Staphylococcus aureus</td>
<td>Streptococcus suis</td>
</tr>
<tr>
<td></td>
<td>Haemophilus somnus</td>
<td>Salmonella spp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pigs</td>
<td>Actinobacillus pleuropneumoniae</td>
<td>Escherichia coli</td>
<td>Brachyspira Samonella sp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Salmonella spp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poultry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Escherichia coli</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Vibrio spp.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Aeromonas spp.</td>
</tr>
</tbody>
</table>

**Enterohaemorrhagic Escherichia coli**

Enterohaemorrhagic E. coli, such as the serotype O 157 which is pathogenic to humans but not to animals, may be included in resistance monitoring and surveillance programmes, provided that adequate laboratory security measures are in place. To date, experience from studies of bovine isolates of E. coli O 157 indicates that the prevalence of resistance is similar to that of commensal E. coli (7).

**Commensal/indicator bacteria**

Escherichia coli and enterococci are commensal bacteria common to all animals. These bacteria are considered to constitute a reservoir of resistance genes, which may be transferred to pathogenic bacteria causing disease in animals or humans. It is considered that these bacteria should be isolated from healthy animals, preferably at the abattoir, and be monitored for antimicrobial resistance.

Escherichia coli and enterococci should be isolated using solid media without antimicrobials. Various enterococcal species may be considered for inclusion in monitoring programmes, but it seems reasonable always to include Enterococcus faecium (4, 14). For antimicrobial resistance traits of special interest, and where prevalence is expected to be very low, more sensitive isolation procedures may be required. In such cases, enrichment in broth containing a selective concentration of the antimicrobial of interest can be used in addition to solid media (8). Identification should follow standard methods used at nationally designated laboratories (2, 5).

For susceptibility testing of commensal bacteria, validated methods should be used (see Antimicrobial resistance: standardisation and harmonisation of laboratory methodologies for the detection and quantification of antimicrobial resistance).
standardisation and harmonisation of laboratory methodologies for the detection and quantification of antimicrobial resistance).

**Antimicrobials to be used in susceptibility testing**

All clinically important antimicrobial classes used in human and veterinary medicine should be monitored. However, the number of tested antimicrobials may have to be limited according to the financial resources of the country in question. A suggested selection of antimicrobials that may be considered for inclusion in national monitoring programmes is presented in Appendix B. The proposed list includes almost all major classes of antimicrobials used to treat both animal and human bacterial infections. In susceptibility testing, some of the proposed antimicrobials are also commonly used as representatives for other antimicrobials belonging to the same class. In general, bacteria that are for example, resistant to erythromycin or tetracycline, are also resistant to most other macrolides or tetracyclines, respectively.

**Standardised susceptibility testing**

See Antimicrobial resistance: standardisation and harmonisation of laboratory methodologies for the detection and quantification of antimicrobial resistance.

**Quality control – quality assurance**

See Antimicrobial resistance: standardisation and harmonisation of laboratory methodologies for the detection and quantification of antimicrobial resistance.

**Type of quantitative data to be reported**

See Antimicrobial resistance: standardisation and harmonisation of laboratory methodologies for the detection and quantification of antimicrobial resistance.

**Database design and recording of results**

Member Countries should give careful consideration to database design for antimicrobial monitoring and surveillance programmes. This is because of the volume and complexity of the information and the probable need for access over a long period of time. The storage of raw (primary, non interpreted) data is essential in order to allow for the evaluation of the data in response to various kinds of questions, including those arising in the future. However, it is strongly recommended that the strains are stored for an even longer period for future analysis.

Consideration may need to be given to technical requirements of computer systems when an exchange of data between those different systems (comparability of automatic recording of laboratory data and transfer of these data to resistance monitoring programmes) should be envisaged.

Results should be entered into a suitable national database and recorded quantitatively, for example as distribution of minimum inhibitory concentrations (MICs) in milligrams per litre or inhibition zone diameters in millimetres (2, 4, 12, 15, 20, 21). The information should include at least the following aspects:

a) sampling programme

b) sampling date
c) animal species/livestock category
d) type of sample
e) purpose of sampling

f) geographic origin of herd, flock or animal
g) age of animal.

The reporting of laboratory data should, where relevant, include the following information:

a) identity of laboratory

b) isolation date
c) reporting date
d) bacterial species
e) serovar
f) phage-type
g) antimicrobial susceptibility result/resistance phenotype.

The proportion of isolates regarded as resistant should be reported, with defined breakpoints. In the clinical setting, breakpoints are used to categorise bacterial strains as susceptible, intermediate susceptible or resistant (6). These breakpoints, often referred to as clinical or pharmacological breakpoints, are elaborated on a national basis and vary between countries (10, 17, 20). The system of reference used should be recorded. For surveillance purposes, another type of breakpoint, the microbiological breakpoint, based only on the distribution of MICs or inhibition zone diameters of the specific bacterial species tested is preferred. When using microbiological breakpoints, only the bacterial population with acquired resistance that clearly deviates from the distribution of the normal susceptible population will be designated as resistant (17). Furthermore, the recording of the phenotype (resistance pattern) of isolates is also very important.

**Reporting and analysis of results**

Countries should give consideration to the designation of a national centre, which should assume the responsibilities to coordinate the activities related to the resistance surveillance and monitoring programmes, to collect information at a central location within the country and to produce an annual report on the resistance situation of the country.
Participating laboratories should report results periodically to the national centre. The national centre should have access to the raw data and the complete results of quality assurance and inter-laboratory calibration activities and proficiency testing results (see Antimicrobial resistance: standardisation and harmonisation of laboratory methodologies for the detection and quantification of antimicrobial resistance).

The annual report should include information on the structure of the monitoring system and on the chosen laboratory methods. It is of critical importance that quantitative results are reported in a harmonised way, as MICs or inhibition zone diameters in the form of histograms or as tables on frequency distributions. Additional information of value includes statistics on the number of animals produced, antibiotic use data and antimicrobials authorised for use. If possible, trends in prevalence of resistance should be related to antimicrobial usage data and also to the disease situation in each country.

For the purpose of a risk assessment addressing a particular question, it may be necessary to generate specific information which would be relevant to the model that has been developed for these purposes. In such cases, special reports might be produced in co-operation with the persons responsible for conducting a specific risk assessment.

If countries should envisage the sharing of raw data, the questions of ownership of the data, access to raw data, interpretation of data and publication of reports should be addressed.

Conclusions and recommendations

In many countries, antimicrobial resistance monitoring and surveillance in animal husbandry have recently become a targeted area. Monitoring or surveillance of antimicrobial resistance in bacteria from food is conducted only by a few countries. Monitoring of resistance in commensal bacteria of human origin is conducted by even fewer countries. Acknowledging the different resources available in different countries, co-ordination with other programmes, such as residue monitoring programmes, should be considered.

The extensive experience of the OIE in animal disease monitoring and surveillance may form an important foundation for Member Countries in the consideration of approaches to the monitoring of antimicrobial resistance. However, as this is a new area for most OIE Member Countries, each country should evaluate the overall issue of antimicrobial resistance in animals and animal-derived food and carefully assess its needs. The practical issues of existing technical expertise, economic and resource requirements are important factors to be considered.

Antibiorésistance : harmonisation des programmes nationaux de suivi et de surveillance de l’antibiorésistance chez les animaux et dans les aliments d’origine animale


Résumé

Le Groupe ad hoc d’experts sur l’antibiorésistance créé par l’Office international des épizooties a élaboré une ligne directrice sur l’harmonisation des programmes nationaux de suivi et de surveillance de l’antibiorésistance chez les animaux et dans les aliments d’origine animale. Cette ligne directrice a pour objet de permettre l’obtention de données comparables dans les systèmes nationaux de suivi et de surveillance afin de pouvoir comparer les situations dans différents pays et régions et d’obtenir ensuite des résultats agrégés aux niveaux national, régional et international. Les auteurs donnent une définition de la surveillance et du suivi. Les systèmes nationaux devraient être en mesure de déceler l’apparition d’une résistance et de déterminer la prévalence de bactéries résistantes. Les
données obtenues devraient être utilisées lors de l’évaluation des risques pour la santé publique et contribuer à la mise en œuvre d’une politique de gestion du risque. Plusieurs facteurs spécifiques ont été identifiés pour les besoins d’une telle harmonisation : l’espèce animale, les produits alimentaires, les programmes d’échantillonnage, les espèces bactériennes, les antibiotiques soumis aux tests, les méthodes de laboratoire, la communication des données, ainsi que la structure des bases de données et des rapports.

Mots-clés

Resistencia a los antimicrobianos: armonización de programas nacionales de seguimiento y vigilancia de la resistencia a los antimicrobianos en animales y alimentos de origen animal


Resumen
El Grupo Ad hoc de expertos sobre la resistencia de las bacterias a los productos antimicrobianos de la Oficina Internacional de Epizootias ha elaborado una directriz sobre la armonización de programas nacionales de seguimiento y vigilancia de la resistencia a los antimicrobianos en animales y alimentos de origen animal, pensada para que puedan obtenerse datos comparables a partir de distintos sistemas nacionales de vigilancia, lo que a su vez serviría para comparar la situación en diferentes países o regiones y elaborar datos agregados a escala nacional, regional e internacional. Los autores ofrecen la definición de “vigilancia” y “seguimiento”. Los sistemas nacionales deben ser capaces de detectar la aparición de resistencias y determinar la prevalencia de bacterias resistentes. Esa información debe servir después para evaluar los riesgos para la salud pública y ayudar a definir programas de gestión de riesgos. A juicio de los autores, los principales elementos que conviene armonizar son: las especies animales, los productos alimentarios, los programas de muestreo, las especies bacterianas, los antimicrobianos analizados, los métodos de laboratorio, la forma de presentar los datos y la estructura de bases de datos e informes.

Palabras clave
Appendix A

Sample size estimates for prevalence of antimicrobial resistance in a large population

<table>
<thead>
<tr>
<th>Expected prevalence</th>
<th>90% Desired precision</th>
<th>Level of confidence</th>
<th>95% Desired precision</th>
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<tbody>
<tr>
<td></td>
<td>10%</td>
<td>5%</td>
<td>1%</td>
</tr>
<tr>
<td>10%</td>
<td>24</td>
<td>97</td>
<td>2,429</td>
</tr>
<tr>
<td>20%</td>
<td>43</td>
<td>173</td>
<td>4,310</td>
</tr>
<tr>
<td>30%</td>
<td>57</td>
<td>227</td>
<td>5,650</td>
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<tr>
<td>40%</td>
<td>65</td>
<td>260</td>
<td>6,451</td>
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<tr>
<td>50%</td>
<td>68</td>
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<td>6,718</td>
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<td>60%</td>
<td>65</td>
<td>260</td>
<td>6,451</td>
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<tr>
<td>70%</td>
<td>57</td>
<td>227</td>
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<tr>
<td>80%</td>
<td>43</td>
<td>173</td>
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</tr>
<tr>
<td>90%</td>
<td>24</td>
<td>97</td>
<td>2,429</td>
</tr>
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</table>

Calculations based upon Epi Info v6.04b to c Upgrade, October 1997, Centers for Disease Control (public domain software available at http://www.cdc.gov/epo/epi/epiinfo.htm)

Appendix B

Proposed list of antimicrobials which, as a first step may be included in antimicrobial resistance surveillance and monitoring programmes

<table>
<thead>
<tr>
<th>Antimicrobial</th>
<th>Salmonella/Escherichia coli</th>
<th>Campylobacter</th>
<th>Enterococcus</th>
<th>Animal pathogens, Gram-positive</th>
<th>Animal pathogens, Gram-negative</th>
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<tr>
<td>Beta-lactams</td>
<td></td>
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<tr>
<td>Penicillin G</td>
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<tr>
<td>Ampicillin</td>
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<tr>
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<tr>
<td>Amoxi/Clav</td>
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<tr>
<td>Cephalosporins</td>
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<td>Macrolides</td>
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<td>Aminoglycosides</td>
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<td>Sulphonamides</td>
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References


