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Systematic review

Review of antimicrobial resistance surveillance programmes in livestock and their meat in Europe, with a focus on antimicrobial resistance patterns in humans

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ABSTRACT

Objectives: In this review, we describe surveillance programmes reporting antimicrobial resistance (AMR) and resistance genes in bacterial isolates from livestock and meat and compare them with those relevant for human health.
Methods: Publications on AMR in European countries were assessed. PubMed was reviewed and AMR monitoring programmes were identified from reports retrieved by Internet searches and by contacting national authorities in EU/European Economic Area (EEA) member states.
Results: Three types of systems were identified: EU programmes, industry-funded supranational programmes and national surveillance systems. The mandatory EU-financed programme has led to some harmonization in national monitoring and provides relevant information on AMR and extended-spectrum β-lactamase/AmpC– and carbapenemase-producing bacteria. At the national level, AMR surveillance systems in livestock apply heterogeneous sampling, testing and reporting modalities, resulting in results that cannot be compared. Most reports are not publicly available or are written in a local language. The industry-funded monitoring systems undertaken by the Centre Européen d'Etudes pour la Santé Animale (CEESA) examines AMR in bacteria in food-producing animals.
Conclusions: Characterization of AMR genes in livestock is applied heterogeneously among countries. Most antibiotics of human interest are included in animal surveillance, although results are difficult to compare as a result of lack of representativeness of animal samples. We suggest that EU/EEA countries provide better uniform AMR monitoring and reporting in livestock and link them better to surveillance systems in humans. Reducing the delay between data collection and publication is also important to allow prompt identification of new resistance patterns. **R. Schrijver, Clin Microbiol Infect 2017;■:1**

Introduction

Antimicrobial resistance (AMR) is a global threat for human and animal health. In 2013, AMR was indicated as one of the major global risks at the World Economic Forum: 'While viruses may capture more headlines, arguably the greatest risk of hubris to human health comes in the form of antibiotic-resistant bacteria' (http://www3.weforum.org/docs/WEF_GlobalRisks_Report_2013.pdf). The EU has also addressed the issue of AMR and has set up an EU-wide antibiotic resistance control strategy by specific action plans (http://ec.europa.eu/dgs/health_food-safety/amr/action_eu/index_en.htm).

Of particular concern is the high use of antibiotics in animal production, as this may lead to increased resistance of animal and human pathogens [1]. The European Medicines Authority (EMA) reports annually on the sales of veterinary antimicrobial products for 29 EU/European Economic Area (EEA) countries. The 2016

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report from 25 countries observed an increase in sales of more than 5% in six countries (http://www.ema.europa.eu/docs/en_GB/document_library/Report/2016/10/WC500214217.pdf). The association between antibiotic usage in animal and development of resistance in commensal bacteria has been clearly described in *Escherichia coli* [2]. Of even more concern is the transmission of resistant bacteria from food-producing animals to humans. Leverstein-van Hall et al. [3] showed many genetic similarities between extended-spectrum β-lactamase (ESBL)-positive *E. coli* isolates from humans and those from poultry. In addition, the fact that resistance can be horizontally transmitted among unrelated bacteria by exchange of resistance genes in the form of plasmids poses an even greater risk for public health [4].

Because of high antibiotic usage, intensive farming and globalization, transmission of AMR from livestock to humans is a major risk today. Therefore, multinational research and laboratory surveillance networks for continuous detection of AMR in bacteria that pose risks to humans and animals are crucial for early detection of increasing resistance patterns across Europe. Various European countries have set up national monitoring programs, most of them focused on zoonotic and indicator bacteria, in line with the mandatory EU legislation (Directive 2003/99/EC; EU Decision 2013/652/EU). The European Food and Safety authority receives data from all 29 EU/EEA countries and compiles them in annual reports. A private organization, the Centre Européen d'Etudes pour la Santé Animale (CEESA), implements antimicrobial susceptibility surveillance programmes [5,6]. However, bacteria and antibiotics of veterinary and human interest differ, and depending on the aim, veterinary surveillance programmes may not necessarily include bacteria of human interest, although such information might be valuable. Presently it seems that the 'one-health concept,' particularly integrating AMR detection in humans and animals, is not well reflected in current veterinary or human surveillance systems.

The main objective of this review was to describe national and supranational surveillance and monitoring programmes and networks collecting multiannual data on AMR in bacterial isolates and resistance genes from livestock and meat in the 31 EU/EEA member states (MSs) and to compare the antibiotics and bacteria monitored with those relevant for human health. Secondary objectives included availability, timeliness and transparency of results.

Methods

Relevant peer-reviewed articles were identified by a review of the literature in order to identify published networks of veterinary surveillance systems. The literature was structurally reviewed with a time span of 10 years (published 2006–2016) using the search terms 'antimicrobial resistance' or 'antimicrobial susceptibility' and 'livestock' or 'cattle' or 'bulls' or calves' or 'veal calves' or 'pigs' or 'fatteners' or 'poultry' or 'chicken' or 'turkey' or 'broilers' and 'surveillance' and 'Europe' or 'European.' A two-step search strategy was performed. First, text words contained in the title, abstract and index (MeSH) terms in PubMed along with title searches were performed. Then the reference lists of all identified reports and articles were searched for additional studies. Inclusion criteria were as follows: published scientific and grey literature; multiannual longitudinal sampling data; data on at least AMR in livestock or meat thereof; and surveillance systems providing or with the intention to provide data on periodic basis. Exclusion criteria were single cross-sectional studies; within-herd transmission studies; epidemiologic studies or reports for which the main objective was different than providing surveillance data; outbreak reports; studies outside the EEA; and reports with only human data. No language restriction was applied.

Multiannual programmes on AMR of bacterial isolates from livestock and meat were further identified from reports retrieved by Internet searches and by contacting national authorities in EU/EEA MSs or representatives of national as well as European organizations active in AMR recording. The reliability of the reports was assessed by verifying the source. Only reports published by national authorities in EU/EEA MSs or reports published by national or official European organizations active in AMR surveillance were used.

Data were extracted independently from two reviewers and were included in a database. The following variables were collected: name of surveillance, country, bacteria surveyed, timing of reporting, quality control, dissemination strategy, antibiotics tested and methods to define resistance (diffusion or dilution tests), type of tests and breakpoints used (European Committee on Antimicrobial Susceptibility Testing (EUCAST) or Clinical and Laboratory Standards Institute (CLSI) epidemiologic or clinical cutoff values) [7,8].

Results

Three different types of surveillance systems for livestock and meat were identified: EU surveillance systems, industry financed supranational surveillance systems and national surveillance systems.

We included 40 reports in total in the study, 30 publications directly identified via PubMed and ten additional reports via open Internet searches and contacting experts, or via checking reference lists; six reports on EU-financed antimicrobial monitoring programmes and industry-financed programmes and 34 reports on national AMR surveillance programmes were retrieved and studied. For ten countries, information on national AMR surveillance systems was retrieved from contacted competent authorities or institutes responsible for AMR studies in livestock. Thirty peer-reviewed articles were screened to identify published networks of veterinary surveillance systems.

EU-financed antimicrobial monitoring programmes

The results of EU surveillance systems in food-producing animals and meat are published in a joint report from the European Food Safety Authority (EFSA) and the European Centre for Disease Prevention and Control (ECDC) based on reporting EU/EEA MSs [8], and are in many occasions also included in national reports. The joint EFSA/ECDC report provides instructions for participating MSs how to test for *Salmonella* spp., *Campylobacter jejuni* and *Campylobacter coli*, indicator commensal bacteria *Enterococcus* spp., *E. coli* and ESBL-, AmpC- or carbapenemase-producing *E. coli* obtained from bovids, pigs and poultry at the farm, slaughterhouse and derived meat sampled at the retail level.

Industry-financed supranational programmes

A nongovernmental initiative is the antimicrobial monitoring undertaken by CEESA, financed by the veterinary pharmaceutical industry. Although CEESA projects are co-owned by industry, results are presented to peer-reviewed journals to ensure independent reporting. This initiative intends to create insight in AMR development to provide an alert for the pharmaceutical companies to increase resources in research and development of new antibiotics. CEESA conducts four AMR resistance surveillance and monitoring programmes across Europe: European Antimicrobial Susceptibility Surveillance in Animals (EASSA), VetPath, ComPath and MycoPath. The industry's EASSA examines the antimicrobial susceptibility of zoonotic and commensal bacteria in healthy food animals [5].

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