Antimicrobial use in animals: a journey towards integrated surveillance

M. Jeannin (1), M. Magongo (1), D. Gochez (1), O. Valsson (1), E. Erlacher-Vindel (1), M. Arroyo Kuribreña (2) & J. Yugueros-Marcos* (1)

(1) Antimicrobial Resistance and Veterinary Products Department, World Organisation for Animal Health, 12 rue de Prony, 75017 Paris, France

(2) International Standards and Science Directorate, World Organisation for Animal Health, 12 rue de Prony, 75017 Paris, France

*Corresponding author: j.yugueros-marcos@woah.org

Summary

In 2015, the World Organisation for Animal Health (WOAH, founded as OIE) initiated the collection of data on the antimicrobial use (AMU) intended for use in animals, using a Microsoft Excel questionnaire. In 2022, WOAH is migrating to a customised interactive online system: ANIMUSE Global Database. This will enable national Veterinary Services to not only monitor and report data more easily and more accurately, but to also visualise, analyse and use data for surveillance purposes, to their own benefit in the implementation of National Action Plans (NAPs) on antimicrobial resistance (AMR). This journey started seven years ago, with progressive improvements on the way data are collected, analysed and reported. A journey plenty of continuous adaptations to overcome different challenges encountered (i.e. data confidentiality, training of civil servants, calculation of active ingredients, standardisation to enable fair comparisons and trend analyses, data interoperability, etc.). Technical developments have been key in the success of this endeavour. However, we must not underestimate the importance of the human element: listen to our Members, to their needs, exchange to solve issues, to adapt tool, to gain and maintain trust. The journey is not over yet, and more evolutions are foreseen, such as: complement current data sources with data collected

directly at the farm level, strengthen interoperability and integrated analysis with cross-sectoral databases, facilitate institutionalisation of data collection, and systematic use in monitoring, evaluation, lesson learning reporting and eventually, surveillance of AMU/AMR when implementing and updating NAPs. This paper describes how all these different challenges were overcome and how those foreseen in the future will be addressed.

Keywords

Antimicrobial resistance – Antimicrobial use – Data collection – Integrated monitoring – Integrated surveillance – One Health – Systems development.

Introduction

The World Organisation for Animal Health (WOAH, founded as OIE) provides, amongst others, standards to ensure availability and utilisation of high quality veterinary products including antimicrobial agents. In 2016 the Organisation published its strategy on antimicrobial resistance and the prudent use of antimicrobials [1]. Monitoring antimicrobial use (AMU) in animals, in conjunction with surveillance of antimicrobial resistance (AMR), provides essential information to empower veterinary services in their assessment and management of risks related to AMR in animal health and beyond. Based on developed standards in this area [2, 3, 4, 5], and within the framework of the Global Action Plan on AMR [6], the creation of a global database on antimicrobial agents intended for use in animals was initiated in 2014. Launched the following year as a Microsoft Excel spreadsheet, it offered a harmonised tool for data collection available in the three official languages of the Organisation (English, French and Spanish). Several evolutions have been made since.

The first one concerned the introduction of an updated methodology to report quantitative data for relevant animal populations, including an analysis of antimicrobial quantities adjusted for animal biomass on a global and regional level [7]. Other upgraded features were added over time, such as a specific Calculation Tool, facilitating data entry and

calculations of antimicrobial quantities. Latest developments move the system away from a Microsoft Excel spreadsheet, to a customised web-based interactive system which, expected for launch by the end of 2022, will facilitate Members' instant access to their data, informing decisions at the national level. In parallel to those evolutions, adaptations were considered to anticipate future integration of data with those collected by other partner organisations working in AMR/AMU (Food and Agriculture Organization of the United Nations [FAO], United Nations Environment Programme [UNEP] and World Health Organization [WHO]). As a first step towards integrated surveillance and joint AMR/AMU analyses across sectors, a consolidated web portal is intended to show monitoring data collected from human and animal health sectors.

Technical developments are worthless if we forget the human element: information, exchange, training, service after launch, mentoring, etc. All these are key success factors in the development, adoption and implementation of data collection tools. In December 2019, first alerts on the emergence of a new respiratory virus appeared in the news. The subsequent COVID-19 pandemic demanded unprecedent adaptations in the way we used to interact and collaborate with data providers and end users. This paper describes the journey of all these developments, both technical and human, both challenges and opportunities, and how all of us, developers and users have adapted to maintain the cap.

Flight plan and take off – some air bumps till cruising altitude

The 1st Global Conference on Responsible and Prudent Use of Antimicrobial Agents, hosted in Paris in March 2013, was a major milestone that paved the way to the launch of a database informing about the use of antimicrobial agents intended for use in animals globally [8].

It all started during the preparation of this Global Conference. A questionnaire was sent to all Members in 2012. The aim was to determine actions needed to develop WOAH's strategy on AMR, in alignment with related standards [2]. This first situational survey was

developed as a printed form sent through postal services accompanied by a digital version by email. Benefitting from the existing network of Focal Points for Veterinary Products, we were able to gather the answers from 85% of WOAH's Members (152/178 at the time). Analysis of results highlighted the lack of monitoring systems: only 41 Members (27%) of the 152 responding had an official system in place collecting quantitative AMU data. This 2012 survey was the first data collection informing about the use of antimicrobials in animals, at global level, in a given point in time. In 2015, the 83rd General Session of WOAH endorsed a resolution giving birth to the development of quality procedures and detailed guidance for an annual data collection among Members on the use of antimicrobial agents in food-producing animals [9].

The first data collection template was developed by an *ad hoc* Group on AMR, constituted by international experts on the topic, using a spreadsheet file. The Group also developed guiding documents for quality filling [3, 4, 10, 11]. These documents, presented to Focal Points for Veterinary Products of all WOAH regions, were consequently enriched and adapted. All this work resulted in a Microsoft Excel-based data collection template, enabling all countries to contribute, regardless of their level of advancement in AMU data collection. Furthermore, the use of a spreadsheet format provided flexibility enough to easily adapt the template upon feedback from participants, as well as from trial and error experiences. Besides, it also made the questionnaire definitely accessible to every participant, regardless their computer skills and know-how. With all that set, capacity building efforts upon system launch could be focused towards actual data collection, rather than to master the reporting tool itself. The finalised documents were used in the first round of data collection launched in October 2015, which was exclusively sent by email to all Members.

First weeks after going live were rich in feedback and learnings, leading to immediate tool improvements with macros and automated sets of tasks. Something unexpected was the large diversity of spreadsheet software used by Members, some with outdated versions, resulting in errors when trying to open our upgraded template. Therefore, we

decided to remove automated features to work on a simplified spreadsheet version, which was shared with all Members one month after the initial launch. Interestingly, many efforts had been deployed to integrate Members needs during template development, aiming at ensuring a common understanding of template questions, data to be collected and how to report them. Nevertheless, once launched, our experience showed the power of monitoring tools, the importance of prompt adaptations and how the reporting tool itself can quickly become an obstacle. Thus, it is also critical during the initial development phases, to not only consider needs from users, but the technical resources they would have at their disposal when implementing the conceived tools.

As a result of the full experience during the first cycle of data collection, in collaboration with the AMR *ad hoc* Group, we improved template and guiding documents to clarify and to simplify the process for Members. These upgrades, mostly focused on formatting the template for minimising data errors and misinterpretation, were used for the second round of data collection, launched in September 2016.

Flying at cruising altitude – consolidation of the system

Since 2016, a series of evolutions were considered and implemented to maintain Member's participation and increase accuracy of collected data.

The development of an analysis denominator (WOAH Animal Biomass methodology) was set to compare quantitative data reported on antimicrobial agents intended for use in animals across regions and over time. The need to evaluate these data in the context of relevant animal populations, which vary in size and composition, is already highlighted in WOAH Standards [3, 4] and within the methodology developed by the AMR *ad hoc* Group [12]. The overall objective of the methodology is to obtain the biomass of animals present during the year of analysis, in a specific country, using internationally and publicly available data [13]. The strength of the methodology comes from the uniformity of animal population data sources used and the high standardisation of

calculations, allowing a significant comparability of indicators globally [14]. Main limitation of the methodology comes from the lack of granularity of the available animal population data. To overcome this barrier the AMR *ad hoc* Group worked in consultation with the WOAH World Animal Health Information and Analysis Department, responsible for collecting data on animal population, through the World Animal Health Information System (WAHIS) Annual Report. A common planning of the evolution of animal population reporting categories was agreed to achieve a higher granularity of such data and a greater robustness of WOAH Animal Biomass denominator over time.

Through the development of this weight-based indicator, and the increased participation to the data collection, capacity to measure trends over time has progressed each year, allowing effective comparisons on global and regional scales. Up to date, a total of 72 countries have been included in the trend analysis of the 6th annual report, demonstrating a 27% reduction in the antimicrobial quantities adjusted by the animal biomass over a three year period from 2015 to 2018 [15]. In the prospect of integrated monitoring and subsequent analysis of AMU across sectors, the animal biomass indicator will be key. Indeed, weight based indicators based on the estimated weight of humans or animals treated, are already being used in other antimicrobial monitoring and surveillance programmes [16].

As the data collection cycles succeeded, the number of participating countries kept increasing. However, 20% to 25% of respondents seemed to face same barriers year after year, impeding them to report AMU quantitative data. Countries without a sophisticated database able to track veterinary products expressed their burden in making some computations required by our template: i.e., calculation of kilograms of active ingredients and use of conversion factors for International Units (IU). Some Members, in particular all those which had not developed a national AMU data collection system, experienced high workload when going through these calculation steps, reason why we decided to develop a secondary optional spreadsheet, the WOAH Calculation Tool, in order to assist countries in calculating antimicrobial quantities.

Tool includes, by entering the veterinary product level information, different units of measurement (milligram [mg], gram [g], millilitre [ml], IU, etc.), providing relevant conversion factors, automatically calculating quantities of active ingredients, and allocating them under the different antimicrobial classes within the right Reporting Options level of our template. Directly within the Calculation Tool, a set of tables and graphs enable the Members to visualise collected data. The initial analysis provided facilitates an initial data checking step at the source, empowering them with reporting capabilities for their own national use.

Between October 2019 and February 2021 this Calculation Tool was piloted and improved through either general trainings or dedicated workshops with National Focal Points for Veterinary Products. After these trainings, 25% to 30% of Members started using the Calculation Tool to report antimicrobial quantities, with a third of them providing quantitative data for the first time. Once again, the success of this initiative can majorly be attributed to the careful introduction of this tool and constant interaction with Members. In each step, valuable feedback was collected from them, improving developed features according to their needs.

The introduction of the WOAH Calculation Tool can be seen as a major step in the data collection process, not only for alleviating workload, but for allowing Members to self-check data, increase accuracy and more importantly, for enabling them to move from qualitative to quantitative reporting of data.

Validation of data is an essential step to ensure accuracy, consistency, reliability and comparability overtime. With every round of data collection, we thoroughly review reported information and systematic contact reporting Members through email communication for approximately 80% of the dossiers. Aim is to clarify grey areas, strengthen the analysis of the data provided and remove inconsistencies often detected when analysing historically submitted data. In average, more than 600 emails exchanges, dozens of videoconferences and telephone calls occur at each round of data collection, providing

essential context to allow us understand data, trends and barriers to overcome. This is a human interaction based exercise which is key in getting a larger perspective and quality contextual information about the AMU situation at the local level. Noteworthy, these exchanges are also key in building trust, and improving the knowledge of the country respondent on their own AMU data.

Last, but not at all least, is the AMU Annual Report WOAH publishes every year, and releases data and analyses. The Annual Report is one of a kind, as it provides a situational analysis on the use of antimicrobials in animals worldwide, with regional and global analysis perspectives, enabling to better understand the current situation, for a given year, as well as over time. It highlights the increased capacity for country monitoring and accurate collection of data, establishing baselines for countries to monitor the implementation of their National Action Plans (NAPs) against AMR in the animal sector. Developed since the first edition and adapted through the years, the report is also a communication tool. It contributes to spread awareness and to educate on the responsible and prudent use of antimicrobials, highlighting progress and areas for further effort, being also a surrogate indicator for the implementation of WOAH standards on AMU. As such, it is planned that some features will also be incorporated in the Observatory.

Match one – from excel to an interactive system

With the AMU Global Database consolidated, Members recommended through Resolution no. 4 of the 2nd OIE Global Conference on Antimicrobial Resistance and the Prudent Use of Antimicrobials in Animals: Putting Standards into Practice, held in 2018, in Marrakesh, Morocco, 'To further develop the OIE data collection on Antimicrobial Agents Intended for Use in Animals, converting the current spreadsheet format to a database system, able to accommodate data submissions by animal species, and its connection to the World Animal Health Information System (WAHIS) and also allowing addition of data from field studies.' [17].

The success of the data collection, the desire for improved transparency, and the effective use of the data in support of Members enabled WOAH

to embark on a programme to advance the existing methodology into a customised interactive online system: the ANIMUSE Global Database. We sought to deliver a software tool where Members will be able to complete data entry requirements, calculate the amount of antimicrobials, and have their animal biomass estimated through access to an online portal. Such database would provide Members functional access to review, analyse, report, and use their own data alongside WOAH's responsibility for global data aggregation and analysis. On the other hand, the ANIMUSE Global Database would automate the current manual processes for data validation, error detection and email communication, alleviating workload for both Members and WOAH's staff. Data validation process would be automated through the use of country dossiers, application of pending flags on questions that need clarification, and the use of the inbuilt business intelligence tool and administration module, to analyse in the context of previous data submissions. Error detection and smart data checks (e.g., previous data comparison) would help countries with the submission of high-quality data. ANIMUSE would also have an inbuilt chat tool and a helpdesk application, to maintain an effective communication and providing tailored support to countries.

WOAH initiated the design specifications for the online database platform from 2018 to 2020, through dedicated AMU workshops which served as requirements elicitation exercises, in order to take into consideration Members' needs. They confirmed the need to integrate calculation assistance and error detection mechanism to ensure better data quality. Readily accessible data and a dynamic data analysis tool were also considered crucial by Members to support key decisions in their NAPs. All this led to the development phase of the ANIMUSE platform. From 2020 to 2022, we used the Agile system development methodology [18], enriched by the collective expectations and the feedback from external experts appointed by the AMR Working Group on AMR, as well as from WHO, FAO and European Surveillance of Veterinary Antimicrobial Consumption observers. The Agile methodology allowed WOAH to have project visibility, transparency, constant feedback, and involvement of various stakeholders for the implementation of a superior quality database platform. To further

improve the development of the ANIMUSE Global Database, a testing phase has been extended to colleagues in the WOAH regions and more importantly with 15 countries around the world between November 2021 and April 2022. Feedback from this testing phase was positive and encouraging for its launch during the 8th round of data collection.

Innovation and technological improvements alone do not bring the desired results without the implementation of a holistic change management programme [19]. In order to achieve the desired uptake and adoption by countries, ANIMUSE design includes the development and implementation of change management using the Awareness, Desire, Knowledge, Ability and Reinforcement (ADKAR) methodology [20]. This includes the development of awareness and guidance material as well as induction training for data providers at country level. The objective is to implement an efficient change management process based on best practices that will help Members to understand, commit to, accept, and embrace changes brought by the ANIMUSE Global Database implementation. User guides, videos, factsheets, training material and email templates were developed as part of the change management process to ensure countries adapt easily to the new processes.

Flying higher, flying with others – heading towards integrated surveillance

ANIMUSE is expected to be launched when kicking off the eighth data collection round, by September 2022. During this round, hybrid data submissions will be allowed. Members will be able to either fill data directly online or to send their classical Excel template, which will be automatically integrated into the ANIMUSE Global Database. WOAH is ready, as it was done in 2015, to interact with and assist Members. Evolutions and adaptations will be likely needed till a new era of AMU data collection, analysis and reporting is consolidated.

ANIMUSE will in the future provide the opportunity for Members to connect directly with national AMU database systems through Application Programming Interfaces and include field level studies information in order to improve accessibility, accuracy, and

coordination from multiple data sources. Countries currently have the possibility to import comma-separated values (more commonly known as CSV) files to simplify product level data entry especially if data are to be extracted from a national AMU monitoring system. ANIMUSE directly contributes to the One Health integrated systems project of Quadripartite members (FAO, UNEP, WHO and WOAH) by providing potential opportunities for greater technical harmonisation of global monitoring AMU data systems and ultimately contribute to global surveillance actions, reducing the health risks at the human–animal–ecosystem interface.

In line with its vision of greater transparency, ANIMUSE will provide the Members the opportunity to choose the level of confidentiality for their validated data: confidential, semi-public, or public. In parallel to this, the way the AMU Annual Report is structured and disseminated is planned to evolve. While keeping the level of confidentiality that Members will choose, design of infographics and interactive visualisations will be developed in parallel to better show global and regional situational analysis. A summarised report consolidating and analysing essential results, important trends, progresses and areas to focus further efforts will be edited, in addition to a full comprehensive and thorough report for those who wish to dive into details. Enabling Focal Points for Veterinary Products and WOAH Delegates to use their AMU monitoring data in surveillance programmes, within the further implementation of NAPs, and influence relevant policy makers, must remain our principal goal. Inspired by the past, consultation of Members will be organised to redefine the AMU Annual Report and other associated communication tools.

Since the beginning, WOAH has been tackling AMR with a One Health approach. Integrated surveillance of AMR/AMU across sectors will be key in helping us to understand the global situation and define joint action plans to control AMR more effectively. The re-development of WOAH's WAHIS, has provided the opportunity for systems compatibility, so that the annual data collection process can potentially be streamlined into one global data system ensuring compatibility with data platforms from other Quadripartite members. ANIMUSE will

therefore be part of the integrated system for monitoring on AMR/AMU platform, which intends to make available in a user-friendly manner on a global and regional basis validated and official data provided by countries to Quadripartite partners on patterns and trends in AMU and AMR in humans, animals, food, plants, and eventually in the environment. A first step in the journey to integrated analyses and surveillance across sectors.

Conclusions

Since 2015 WOAH has been collecting, analysing and reporting global data on antimicrobial use intended for use in animals, as a mean to strengthen knowledge through harmonised monitoring. A major success since the very beginning has been the incredibly high rate of participation, even though AMU data collection systems were not established by a large majority of Members. Based on a trust relationship and the power of our network, we established patient, systematic and successive rounds of exchanges with Members. These have been key in the progressive deployment and continuous improvement of this common database, being altogether an essential learning we must not forget and further leverage during the launch and implementation of ANIMUSE.

AMU data is a crucial asset that creates value on various possible aspects at global, regional and country level. It is not solely about monitoring data, but it is about building the knowledge to collect them, understand them, analyse them and act on them. In order to do so, developing the adequate tools and answering to the needs expressed by the end-user is critical. ANIMUSE is integrated with a powerful business intelligence tool that helps countries create deeper and more helpful insights from their data. These insights can inform decisions and turn them into actions. The evolution of this tools responds to the objectives of WOAH Standards [3, 5]. Maintaining the momentum, keep listening to the voice of our Members, and showing them the power of data for surveillance programmes, for their own benefit, would be essential. Time has come to further engage with Members and move AMU data collection into next stages through national

institutionalisation. Technical developments should enable Members to utilise their own monitoring data, bringing them to a deeper level of knowledge and action, or in other words, moving from monitoring to surveillance.

Simultaneously, WOAH is exploring how to foresee a possible link with AMU studies taking place within the countries at field level. Farm/clinic level AMU represents the true monitoring of antimicrobials administered to animals for any purpose, and therefore can wisely complement data collected through national services. Those data can deepen the knowledge on the reasons for use, quality of veterinary products and species-specific estimates of AMU quantities in comparison to the ones originating from sales or imports data at national level. WOAH is currently seeking to record project methodologies, provide access to data providers and enhance collaborations within and between countries for a coordinated action against AMR, through the identification of past and on-going projects on AMU at field level.

First steps towards integrated surveillance are being made through the establishment of compatible monitoring tools with our Quadripartite partners. While this would allow to have in a same platform all available global data related to AMU/AMR across sectors, further steps must be undertaken to allow the incorporation of environmental monitoring data and joint analyses for better assessment of the situation and the interplay of different sectors related to AMR. The joint inter-agency report on integrated analysis of antimicrobial agent consumption and occurrence of antimicrobial resistance in bacteria from humans and food-producing animals in the European Union/European Economic Area and the Canadian Antimicrobial Resistance Surveillance System Report are examples of possible analysis of multiple sectors at regional level [16, 21].

AMR is a global threat with impact on livelihoods, food security, animal and human lives. Rising levels of AMR will hinder progress towards many of the United Nations Sustainable Development Goals (SDGs), including health, well-being and poverty reduction. Tackling AMR effectively requires concerted action across sectors under a One

Health approach, and improved monitoring data is key for successful surveillance [22]. ANIMUSE is the Global database reporting antimicrobial use intended for use in animals. With more than seven years of experience and continuous improvements, we are directly supporting various aspects of SDGs, such as contributing to global health priorities, technological progress, and innovation as well responsible production and consumption.

Acknowledgements

Authors undeniably thank all Civil Servants (i.e. Delegates, Focal Points, etc.) who participate every year in data collection and reporting. Their openness, willingness to help and continuous availability have been, and continue to be key in the success of this work. Without them, this work would be impossible. With them, we can better tackle together the emergence of AMR by promoting a responsible use of antimicrobials worldwide.

Authors would also like to thank all our colleagues from Regional and Sub-Regional Representations. They are an essential part of this success, being at the front end in the interaction with Focal Points.

Authors would also like to thank colleagues from other Departments within WOAH Headquarters: Digital Transformation and Information Systems Department, Data Integration Department, World Animal Health Information and Analysis Department, Engagement and Investment Department, etc. All of them have been crucial in the development, implementation and evolution of our monitoring system.

Authors would like to thank all experts having participated in this journey as members of the AMR *ad hoc* Group or Working Group on AMR. Their insights, suggestions and availability have settled a thorough and reliable basis enabling data collection, interpretation and reporting for the sake of great utility.

Finally, the authors would like to thank all the resource partners having provided financial support to this work from inception to nowadays and beyond: Governments of Australia, France, Italy, Japan, Mexico,

United Kingdom Fleming Fund, United States of America, as well as contributions from the European Union, Pew Charitable Trusts, and World Bank Group.

References

[1] World Organisation for Animal Health (WOAH) (2016). – The OIE strategy on antimicrobial resistance and the prudent use of antimicrobials. WOAH, Paris, France, 12 pp. Available at: https://www.woah.org/fileadmin/Home/eng/Media_Center/docs/pdf/PortailAMR/EN_OIE-AMRstrategy.pdf (accessed on 25 August 2022).

[2] World Organisation for Animal Health (WOAH) (2022). – Chapter 6.8. Harmonisation of national antimicrobial resistance surveillance and monitoring programmes. *In* Terrestrial Animal Health Code. WOAH, Paris, France, 6 pp. Available at: https://www.woah.org/en/what-we-do/standards/codes-and-manuals/terrestrial-code-online-access/?id=169&L=1&htmfile=chapitre_antibio_harmonisation.htm (accessed on 11 July 2022).

[3] World Organisation for Animal Health (WOAH) (2022). – Chapter 6.9. Monitoring of the quantities and usage patterns of antimicrobial agents used in food-producing animals. *In* Terrestrial Animal Health Code. WOAH, Paris, France, 4 pp. Available at: https://www.woah.org/en/what-we-do/standards/codes-and-manuals/terrestrial-code-online-access/?id=169&L=1&htmfile=chapitre_antibio_monitoring.htm (accessed on 11 July 2022).

[4] World Organisation for Animal Health (WOAH) (2022). – Chapter 6.3. Monitoring of the quantities and usage patterns of antimicrobial agents used in aquatic animals. *In* Aquatic Animal Health Code. WOAH, Paris, France, 4 pp. Available at: https://www.woah.org/en/what-we-do/standards/codes-and-

manuals/aquatic-code-online-access/?id=169&L=1&htmfile=chapitre_antibio_quantities_usage_patterns.htm (accessed on 11 July 2022).

[5] World Organisation for Animal Health (WOAH) (2022). – Chapter 6.4. Development and harmonisation of national antimicrobial resistance surveillance and monitoring programmes for aquatic animals. *In* Aquatic Animal Health Code. WOAH, Paris, France, 4 pp. Available at: https://www.woah.org/en/what-we-do/standards/codes-and-manuals/aquatic-code-online-access/?id=169&L=1&htmfile=chapitre_antibio_development_harmonisation.htm (accessed on 11 July 2022).

[6] World Health Organization (WHO) (2015). – Global action plan on antimicrobial resistance. WHO, Geneva, Switzerland, 28 pp. Available at: https://www.who.int/publications/i/item/9789241509763 (accessed on 11 July 2022).

[7] World Organisation for Animal Health (WOAH) (2017). – OIE annual report on antimicrobial agents intended for use in animals: better understanding of the global situation. 2nd report. WOAH, Paris, France, 123 pp. Available at: https://www.woah.org/fileadmin/Home/eng/Our_scientific_expertise/docs/pdf/AMR/Annual_Report_AMR_2.pdf (accessed on 11 July 2022).

[8] World Organisation for Animal Health (WOAH) (2015). – Antimicrobial resistance: standards, recommendations and work of the World Organisation for Animal Health (OIE). WOAH, Paris, France, 15 pp. Available at: https://doc.woah.org/dyn/portal/digidoc.xhtml?statelessToken=6xNBkO1UjdKAZiTc-VlC1JjloKBwLldRPk-ebkl8veM=&actionMethod=dyn%2Fportal%2Fdigidoc.xhtml%3AdownloadAttachment.openStateless (accessed on 21 June 2022).

[9] World Organisation for Animal Health (WOAH) (2015). – Resolution no. 26. Combating antimicrobial resistance and promoting the prudent use of antimicrobial agents in animals. *In* Annual report of

the 83rd General Session of the World Assembly of OIE Delegates, 24–29 May, Paris, France. WOAH, Paris, France, 170–171. Available at: https://www.woah.org/app/uploads/2021/03/a-reso-2015-public.pdf (accessed on 21 June 2022).

[10] World Organisation for Animal Health (WOAH) (2018). – Annex to the guidance for completing the OIE template for the collection of data on antimicrobial agents intended for use in animals. WOAH, Paris, France, 6 pp. Available at: https://www.woah.org/en/document/eng_amuse_annex_to_guidance_final (accessed on 27 June 2022).

[11] World Organisation for Animal Health (WOAH) (2020). – Guidance for completing the OIE template for the collection of data on antimicrobial agents intended for use in animals. WOAH, Paris, France, 10 pp. Available at: https://www.woah.org/en/document/eng_amuse_guidance_final (accessed on 27 June 2022).

[12] World Organisation for Animal Health (WOAH) (2016). – Report of the meeting of the OIE *ad hoc* Group on antimicrobial resistance, 21–23 June, Paris, France. WOAH, Paris, France, 7 pp. https://www.woah.org/app/uploads/2021/09/a-ahg-amr-june2016.pdf (accessed on 27 June 2022).

[13] Góchez D., Raicek M., Pinto Ferreira J., Jeannin M., Moulin G. & Erlacher-Vindel E. (2019). – OIE annual report on antimicrobial agents intended for use in animals: methods used. *Front. Vet. Sci.*, **6**, 317. https://doi.org/10.3389/fvets.2019.00317

[14] Bulut E. & Ivanek R. (2022). – Comparison of different biomass methodologies to adjust sales data on veterinary antimicrobials in the USA. *J. Antimicrob. Chemother.*, **77** (3), 827–842. https://doi.org/10.1093/jac/dkab441

[15] World Organisation for Animal Health (WOAH) (2022). – Annual report on antimicrobial agents intended for use in animals. 6th Ed. WOAH, Paris, France, 132 pp. Available at:

https://www.woah.org/en/document/annual-report-on-antimicrobial-agents-intended-for-use-in-animals (accessed on 27 June 2022).

[16] European Centre for Disease Prevention and Control, European Food Safety Authority & European Medicines Agency (EMA) (2021). – Antimicrobial consumption and resistance in bacteria from humans and animals. Third joint inter-agency report on integrated analysis of antimicrobial agent consumption and occurrence of antimicrobial resistance in bacteria from humans and food-producing animals in the EU/EEA (JIACRA III – 2016–2018). EMA, Amsterdam, the Netherlands, 164 pp. https://doi.org/10.2900/056892

[17] World Organisation for Animal Health (WOAH) (2018). – OIE global conference on antimicrobial resistance: putting standards into practice. Abstract of the 2nd OIE global conference on antimicrobial resistance and prudent use of antimicrobial agents in animals, 29–31 October, Marrakesh, Morocco. WOAH, Paris, France, 86 pp. Available at: https://www.woah.org/fr/document/a_abstract_amr2018-2 (accessed on 20 June 2022).

[18] Edeki C. (2015). – Agile software development methodology. *Eur. J. Math. Comput. Sci.*, **2** (1), 22–27. Available at: https://www.idpublications.org/wp-content/uploads/2015/05/Agile-Software-Development-Methodology.pdf (accessed on 25 August 2022).

[19] Altamony H., Tarhini A., Al-Salti Z., Gharaibeh A.H. & Elyas T. (2016). – The relationship between change management strategy and successful enterprise resource planning (ERP) implementations: a theoretical perspective. *Int. J. Bus. Manag. Econ. Res.*, **7** (4), 690–703. Available at: https://tarjomefa.com/wp-content/uploads/2017/10/7912-English-TarjomeFa.pdf (accessed on 25 August 2022).

[20] Hiatt J.M. (2006). – ADKAR: a model for change in business, government, and our community. 1st Ed. Prosci Learning Center Publications, Loveland, United States of America, 146 pp.

[21] Public Health Agency of Canada (2021). – Canadian antimicrobial resistance surveillance system report: protecting and empowering Canadians to improve their health. Public Health Agency of Canada, Ottawa, Canada, 90 pp. Available at: https://www.canada.ca/en/public-health/services/publications/drugs-health-products/canadian-antimicrobial-resistance-surveillance-system-report-2021.html (accessed on 5 July 2022).

[22] World Health Organization (WHO), Food and Agriculture Organization of the United Nations, World Organisation for Animal Health & United Nations Environment Programme (2021). – Antimicrobial resistance and the United Nations sustainable development cooperation framework: guidance for United Nations country teams. WHO, Geneva, Switzerland, 15 pp. Available at: https://www.who.int/publications/i/item/9789240036024 (accessed on 26 June 2022).