1. Editorial

Three decades of surveillance, decades to come - what awaits us?

Commitment, Continuity, Collaboration - this year the DANMAP programme issues its thirtieth annual report, and these three words stand as important pillars and sum-up the core qualities from long-standing surveillance of antimicrobial consumption and resistance in humans, animals and food.

Thirty years is a considerable period for a surveillance programme. It is long enough to document changes in antimicrobial consumption and resistance, to assess the consequences of interventions and to establish a body of knowledge that extends beyond individual reports. As editors of the report, we would like to use the opportunity to consider not only what has been achieved but also what is required to maintain its value in the years to come.

DANMAP was established in 1995, when the possible, and probable relation between antibiotic usage in animals and occurrence of resistance in humans was gaining increased attention, not only in Denmark but across Europe. It became an area of concern for researchers and politicians alike. The idea behind was simple, yet the task complex: antimicrobial resistance cannot be adequately understood by examining data and findings in a single sector in isolation. The first results covering the food producing and human health sectors were published in 1997, making it evident that a systematic, continuous surveillance programme was necessary to gain more understanding and deliver data for policymaking in the area.

Covering both animals and humans, the programme delivered - and still delivers - a common evidence base for decisions that may otherwise be difficult to evaluate. DANMAP has documented the effects of many measures over time and in many ways, some of them will be addressed below.

From the very beginning of DANMAP, initiatives to reduce antimicrobial use in livestock, including the discontinuation of antimicrobial growth promoters and restrictions on both total and selected antimicrobial agents, led to marked changes, particularly in the pig industry. When VetStat was established in 2000 it further strengthened the possibilities for monitoring veterinary medicine use, while the concurrent development of microbiological diagnostics and national data systems supported increasingly detailed analyses and data comparisons. These again made it possible to look into potential sources and causes for emerging antimicrobial resistances using a a cross-sectoral approach. This led to measures aimed at reducing total usage or shifting toward a more rational application of antimicrobials, both of which have clearly contributed to maintaining low overall resistance levels in Denmark. Such achievements reflect the value of sustained cooperation and data-sharing across the sectors and across research institutions, authorities, farmers and clinical practitioners.

But surveillance is not simply a matter of collecting data and performing cross-analyses. Its value lies in maintaining consistent methods, interpreting findings in their appropriate context and making results available to those responsible for policy and practice. The annual report provides a record against which both progress and emerging problems can be assessed. That record is particularly valuable when the effects of an intervention become apparent only over several years.

However, the speed and order of developments are not always aligned, and progress in one area does not guarantee progress in another. While antimicrobial usage in pigs, after years of continuous reductions from 2011 to 2017, has levelled off in recent years despite strengthened efforts to reduce it further, antimicrobial consumption in humans has shown similar declines a decade ago and, after the fluctuations associated with the COVID-19-pandemic from 2020 to 2023, continues now its markedly declining trends.

Unfortunately, at the same time resistance to certain antibiotics continues to rise in the human sector: resistance to piperacillin-tazobactam among invasive *E. coli* increased over the longer term, causing worries in clinical departments as this is often the common choice of antibiotic treatment of patients upon admission to hospitals. Similarly, the number of carbapenemase-producing enterobacterales (CPE) continued its steep rise in 2025. Although CPE are currently either sporadically imported or outbreak-related and seem to be kept at bay, not showing in the resistance levels of the standard monitoring of bacteraemias yet, these are worrying trends that demand hospital resources and local actions. These developments underline the need to follow individual pathogens, resistance mechanisms and antimicrobial groups rather than relying on aggregate indicators alone.

The food chain represents another important dimension in surveillance, spanning and connecting the food production and the human health sectors. Along with the monitoring of antimicrobial use in the three main food-producing animal species in Denmark, the occurrence of resistance to a wide panel of antimicrobials, including compounds of both veterinary- and human medicine relevance, has been monitored in indicator and foodborne zoonotic bacteria recovered from animals and meat since the establishment of the programme. With the monitoring of resistance in indicator *E. coli* from healthy animals sampled at slaughter, DANMAP has continuously followed the trends of resistance in the Danish animal food-production sector over three decades. Such trends are interpreted in an integrated manner, alongside the trends in antimicrobial consumption, which has repeatedly provided valuable insights for policymakers and other stakeholders.

Similarly, the routine collaborative analysis and reporting of resistances in the foodborne pathogens *Salmonella* and *Campylobacter*, recovered from human patients, animals and meat has been an integral part of the programme since its inception, and it has contributed to monitor and inform the control of resistance in important human pathogens at the animal reservoir level. DANMAP has also repeatedly shown that resistance levels may differ between bacteria from domestically produced and imported meat. The low occurrence of resistance to third- and fourth-generation cephalosporins in *E. coli* from Danish meat is encouraging, while the higher resistance levels often reported in imported meat warrants attention. In a food market characterized by international trade, national production practices alone cannot determine the resistance patterns to which Danish consumers are exposed.

The next phase of DANMAP should build on its established strengths while being attentive to limitations of the programme. The implementation of whole-genome sequencing (WGS) in both outbreak detection and parts of the surveilled areas was a game changer, strengthening the programme´s ability to characterise resistant bacteria and investigate further on relationships between isolates from humans, animals and food. By identifying shared resistance genes and bacterial lineages, and providing evidence relevant to possible transmission between sectors, it has added a new layer of understanding. However, genetic similarity alone does not always establish the direction, frequency or epidemiological importance of transmission. For this, epidemiological information and well-designed sampling still remain essential.

There are also important gaps in the available data. National figures may follow overall trends, but they cannot always demonstrate whether an intervention actually changed prescribing at the level of the individual patient, healthcare unit, farm or production site. Nor does a passive surveillance system constructed around the collection of data from routine clinical isolates necessarily provide a representative picture of the levels of resistance in society or in certain population groups, such as residents of nursing homes.

Addressing these gaps requires choices about priorities, sampling and resources. More or, more detailed data does not necessarily make them better data. Introducing new surveillance activities should always be a response to clearly defined questions, addressing whether it improves the interpretation of existing results or supports decisions that could not be adequately informed by current methods. At the same time, it is important not to withdraw on existing methods or sampling schemes without considering how this can impact the ability to compare results over time.

The conditions under which DANMAP operates are changing. In Denmark, an ageing population demanding changes in healthcare provision and the recently introduced healthcare reform will change the landscape and probably impact sampling and diagnostic schedules. It may also impact the need for effective antibiotics over time.

Another concern is the availability of antimicrobial medicines for both humans and animals and of vaccines for animal production. Shortages may alter prescribing practices and increase the use of alternative agents. It can also stimulate the development of new antimicrobials or new alternatives to antimicrobials, a development that we look forward to, but which should be taken into account when readjusting surveillance programmes.

Food production is also evolving. Foreseen politically demanded changes in production volume, farm management and disease prevention practices may affect antimicrobial use. As production systems and supply chains change and develop, surveillance must remain sufficiently flexible to detect the following changes in bacteria and their resistome.

Also, the political landscape and context are important and can play a crucial role. While national action plans and goals need to be developed according to national needs, they also need to be aligned with and adjusted to international development, the direction set by the European Commission and the recommendations issued by the United Nations and important bodies such as the World Health Organisation, the Food and Agriculture Organisation and the World Organisation for Animal Health. In recent years, this also includes the United Nations Environmental Programme.

DANMAP can contribute by documenting whether intended changes occur and by identifying unintended consequences. Its role is to provide an independent evidence base, always keeping an arms-length distance to the political and professional decisions that follow from it.

In the future, environmental surveillance may become a more prominent part of this work. Resistant bacteria and antimicrobial residues in wastewater, agricultural environments and other environmental compartments can provide information not captured by current human, animal and food surveillance. However, the environmental dimension is methodologically demanding. New sampling approaches and indicators must be sufficiently standardised to allow meaningful interpretation, and their inclusion should be guided by a clear assessment of what they add to the existing programme.

A programme with DANMAP's responsibilities depends on more than scientific methods. It requires stable funding, access to high-quality data, skilled personnel, functioning laboratory networks and effective cooperation between institutions. These conditions should not be taken for granted. Public budgets and political priorities change, while the demands placed on surveillance continue to grow.

There is a risk that the value of long-running surveillance becomes less visible precisely because it has become an established part of the national infrastructure. The absence of a dramatic change in a given year may be reassuring, but it does not mean that the underlying surveillance is unnecessary. Reliable conclusions about trends, interventions and emerging resistance depend on data collected consistently over many years. Interruptions or poorly planned changes may compromise the ability to distinguish real developments from changes in measurement.

On a more practical level, it is important to consider how DANMAP can remain useful to its readers. The detailed annual reports have aimed at delivering satisfactory details and knowledge to researchers, laboratories, clinicians, veterinarians and authorities. The more accessible short report - or summary - has in recent years tried to accommodate the wish for easier and faster communication about main findings. It is a continuous challenge to hit the balance right, to make results easier to understand without simplifying away uncertainty or overstating what the data demonstrate.

Finally, in 2026, Denmark has appointed its high-level representative for AMR.DANMAP looks forward to contributing to this work in order to maintain the awareness on prudent use of antimicrobials and on AMR nationally but certainly also globally.

The 30th anniversary is an opportunity to recognise what DANMAP has achieved, but it should not become a reason for complacency. The programme's enduring strength lies in its continuity, its cross-sector perspective and its ability to turn data into a basis for action. Its future value will depend on maintaining these characteristics while adapting to new scientific possibilities and changing needs. After 30 years, the overall positive developments that DANMAP has reported in antimicrobial consumption and resistance in Denmark demonstrate why surveillance remains necessary. Having little to look for does not mean that we should stop looking. A surveillance programme should be able to document progress without overlooking unfavourable developments, and to distinguish between a temporary fluctuation, a sustained trend and a change that requires intervention, also when the trends are favourable.

At the end remains Commitment, Collaboration and Consistency, words that highlight the engagement and dedication that has been put into DANMAP work over the years. We hope that these words and values will carry DANMAP into its next 30 years. Enjoy reading!

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DANMAP 30 years in the service of One Health

It was a very different time 30 years ago; the Berlin wall had just come down and a new reunified Europe emerged, new molecular techniques were rapidly transforming classical microbiology, digital connectivity and data science were in their early stages, and both political and technical optimism about a new open, free and globally connected world began to take shape.

We hadn't yet worried about climate change, mass extinction of species or political nationalism and AI was not yet invented. However, antimicrobial resistance (AMR) was already a serious concern, and the prospect of humanity losing the race between our ability to discover new antimicrobials and the rapid emergence of new multidrug-resistant pathogens was becoming increasingly realistic.

In Denmark, the detection of vancomycin-resistant *Enterococcus faecium* in food animals, and the association to the routine feeding of avoparcin (a glycopeptide) to food animals as growth promoters, had caused both public and political alarm. The Minister of Food and Agriculture at the time, Henrik Dam Kristensen, boldly banned the use of avoparcin for food animals in Denmark.

Antimicrobial growth promoters were regulated by EU legislation, so a unilateral ban required solid scientific evidence that the banned substance represented an unacceptable threat to human or animal health. The time to provide this comprehensive evidence was a matter of weeks. It quickly became apparent how little data Denmark had on antimicrobial usage and antimicrobial resistance in humans and animals, and in particular in the interface between animals and humans.

We convinced the Minister that in order for Denmark to succeed in Brussels, we would need much better data on the association between antimicrobial use in humans and animals and antimicrobial resistance in human and animal infections, and also continuous data, to document the effect of the ban, as well as the risks to the health of humans and animals.

It was fortunate that Denmark just a little more than one year prior had established the Danish Zoonosis Center, with a mission to document the zoonosis situation in the country annually to the European Commission, and thus an elaborate system for collecting samples from animals, food and humans had been put in place recently, and also a governance and coordination structure involving all public, civic and private relevant stakeholders in the one health arena. The main institutions in the Danish Zoonosis Centre were Statens Serum Institut and Danish Veterinary Institute, and it was those two institutions that prepared the plan for the DANMAP program.

The plan reflected the purpose as well as the surveillance structures already in place in different contexts, not least the Danish integrated zoonosis monitoring program. Unique features of the programme included the diversity of microbial organisms; pathogens and indicators, the sampling system, the harmonized antimicrobial susceptibility testing methods, the antimicrobial consumption data collection and the epidemiological data analysis and visualization framework. The report preparation process, design, lay-out, printing and distribution was copied from the annual report on zoonosis, so we were able to move from plan to execution in a very short time, and the first DANMAP report was published less than a year after the program's initiation.

The DANMAP programme was instrumental in supporting the process of documenting the consequences of the use of, and the effects of terminating the use of antimicrobials for growth promotion. It provided a comprehensive situation report of the AMR situation in Denmark and has continued to do so for thirty years now. That is unique, and DANMAP has rightfully earned its nickname as the "mother of all AMR monitoring programs".

The European ban of the use of antimicrobials for animal growth promotion use remains the world's largest intervention to reduce the selective pressure for AMR globally, but also the voluntary as well as regulatory control of the use of critically important antimicrobials in animals and humans, as well as early detection and response to emerging pathogens such as MRSA, CRO's and others have been crucial. Sadly, antibiotics as growth promoters are still used outside Europe.

DANMAP remains the most comprehensive AMR and AMU monitoring programme globally, and it has been an international role model for many countries worldwide, including the EU integrated AMR monitoring program. DANMAP data has been used in thousands of scientific publications and reports and ensured a constant high level of awareness of the AMR situation in Denmark, informing guideline and regulatory developments as well.

Consistency in sampling plan and analysis methods has been a hallmark of DANMAP, however, in the future, a gradual replacement of conventional laboratory methods by genomic methods seems like a relatively safe prediction. This will however not happen rapidly and will require extensive evaluation and documentation to ensure that genomic data can be translated into phenotypic data of clinical relevance.

Despite the successes of DANMAP, the AMR problems of Denmark and the world around us have definitely not disappeared, on the contrary, thus it is our hope that the programme, which we initiated thirty years ago, will continue to produce solid data to inform experts and decision makers for many decades onwards, as well as inspire other countries to do the same. On this note, we are happy that Henrik can now not only apply and integrate the insights and knowledge gained from his years with AMR surveillance, but also utilize future DANMAP results in his work as the Danish High Level Representative on AMR.

DANMAP remains among the finest Danish solutions to this date.

Niels Frimodt-Møller and Henrik C. Wegener

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