Successful prevention of antimicrobial resistance in animals: a retrospective country case study of Sweden

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According to EU monitoring, Sweden has the lowest use of antibiotics in animals of the EU Member States and the occurrence of antibiotic resistance (AMR) is among the lowest in Europe[1,2]. In a recent study published in the scientific journal *Antibiotics,* we identified key factors behind this favorable situation[3]. The study was inspired by the Global Action Plan by the OIE, FAO and WHO[4] and the EU One Health Action Plan against AMR[5], postulating that lessons learned from successful strategies in individual countries could be valuable for other countries[5]. The study focused on the situation in food producing animals in Sweden and is based on data since the early 1900s. Here we summarise findings in the study by briefly presenting actions taken within the two areas:

1. **Antibiotic use / AMR**
2. **Prevention / control of infectious diseases**

In addition, we present some supporting facts and the major key factors identified in the study. References cited in the study are available in the full publication in *Antibiotics*[3].

Antibiotic use and resistance

Since the mid-1950s, when antibiotics became commonly available for use in animals, prudent use and the risks of AMR have frequently been highlighted by veterinary practitioners and researchers in Sweden. It was recognised early that antibiotics are important tools for the treatment of bacterial infections and that they need to be protected and not considered miracle drugs for dramatically improving animal production.

In 1986, the use of antibiotics for growth promotion (AGP) was banned in Sweden. This put the focus on disease prevention by other means, including measures for improved management, feeding and housing of animals. The use of antibiotics and sustainable animal production became, and still are, important issues on the political agenda and for consumers, which has promoted sustained efforts for a prudent use of antibiotics.

Access to data on the occurrence of AMR, since the late 1950s, and on antibiotic sales, since 1980, has been used to formulate policies, guidelines and legislation and for evaluating the effects of actions taken. This has transformed a general awareness of AMR into concrete knowledge on prudent use and into concrete actions to mitigate emergence of AMR.

During more recent years, actions have been taken to counteract the spread of bacteria with AMR of specific importance. For example, the implementation of a policy on the treatment of mastitis in dairy cows in 1995 reduced the occurrence of penicillin resistant *S. aureus* from 10% to 1%. Another example is an outbreak of tiamulin-resistant *Brachyspira hyodysenteriae* in pig herds in 2016 which was actively curbed. This organism causes swine dysentery, and tiamulin is vital for treatment. Other examples are control of imported animals to minimise the risk of introduction and spread of *E. coli* resistant to extended-spectrum cephalosporins in broiler production and methicillin-resistant *Staphylococcus aureus* in pig production. Also, legislation is in place to mitigate the spread of bacteria with specific AMR in animals, for example carbapenemase-producing Enterobacteriaceae (CPE).

Prevention and control of infectious diseases

For the substantial efforts required for eradication of major epizootic diseases (**Table 1**), State veterinary leadership, veterinary infrastructure and regional veterinary laboratory capacity were established early in Sweden. These later became valuable tools in the prevention of other infectious diseases, including endemic disease. Already in 1945, industry-led animal health counselling services were initiated and in 1969 a regulatory implementation of organised health controls transformed the industry-led health services into coordinated and focused activities. As a result, important endemic diseases could be controlled or eradicated through joint action by the government and the industry.

Hygiene and biosecurity routines on farms and in feed production were implemented early through the control and eradication programmes. Due to a limited and controlled import, and trade within the country, of animals, genes and feed ingredients the introduction and spread of several infectious diseases has been prevented.

Farmers enrolled in organised health controls and organised health services, are provided with farm-specific advice on the management and prevention of diseases through access to veterinary expertise and regular visits by veterinarians. Such visits are also important for compliance with policies and recommendations on biosecurity, the use of antibiotics and good agricultural practice .

Stringent animal welfare regulations are also considered to have improved animal health and decreased the need for antibiotic treatment.

Cooperation in problem solving

Using regulatory and financial tools, the competent authority has facilitated control of infectious diseases and AMR. Cooperation between relevant stakeholders has enabled mutual understanding of the need for and benefits of implementing measures to prevent and control infectious diseases and to counteract AMR. A One Health perspective is taken into account by a cooperation between national authorities in the human and animal sectors facilitating the control of zoonotic diseases and AMR.

Early actions

It is interesting to note that in three areas of major importance for counteracting AMR, Sweden took control actions long before other countries. The control and eradication of several diseases, for example, *Salmonella* infections, Bovine tuberculosis and brucellosis, was initiated early (**Table 1**). A successful control of *Salmonella* has resulted in a virtually salmonella-free animal and feed production. The control was initiated more than 60 years ago following an outbreak which caused the death of 90 people and more than 9,000 cases of illness. In 1980, Sweden became one of the first countries in the world to publish data on sales of antibiotics, and in 1986, also the first country to ban the use of AGPs. Sweden was also comparatively early in setting up a national monitoring programme for AMR in animals (2000).

Summary

Data and experiences in Sweden show that it is possible to combine high productivity in animal production with a restricted use of antibiotics. The major key factors explaining the success of Swedish prevention of AMR are:

- Early insight and continuous awareness of risks associated with AMR and the need for prudent use of antibiotics.
- Early access to data on antibiotic sales and AMR making it possible to focus on activities of concern.
- Early and longstanding efforts to prevent, control and when possible eradicate infectious diseases has reduced the need for antibiotics.

Legal structures, strategies and policies established under government leadership and in cooperation between stakeholder

References

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Year	Disease	Animal Species	Comments
1924–27	Foot and mouth disease (FMD)	Cattle	11,002 herds infected.
1938–40	FMD	Cattle	7293 herds infected.
1940	Classical swine fever (CSF)	Pigs	230 herds infected.
1943–44	CSF	Pigs	445 herds infected.
1950–56	Paratuberculosis	Cattle	Beef cattle, 830 animals seropositive.
1951–52	FMD	Cattle	562 herds, 1 million cattle vaccinated.
1953	Salmonella epidemic	Mainly cattle	9000 human cases, 90 deaths.
1956–57	Porcine brucellosis	Pigs	76 herds infected.
1956–57	Anthrax	Cattle/pigs	19 cattle herds/68 pig herds infected.
1960	FMD	Cattle	6 herds infected.
1993	Paratuberculosis	Cattle	53 beef cattle herds infected.
1991–97	Bovine tuberculosis	Farmed deer	13 herds infected.
1995–96	Newcastle disease (ND)	Poultry	650 flocks tested; 1.75 million birds/eggs destroyed.
2007	Porcine reproductive and respiratory syndrome (PRRS)	Pigs	7 herds infected, modified stamping out.
2008–09	Bluetongue	Cattle	30 outbreaks in different regions, 2.7 million cattle vaccinated.
2010–20	Highly pathogenic avian influenza and ND	Poultry	2 and 5 outbreaks, respectively.
2010–20	Anthrax	Cattle	12 outbreaks.
In addition: National eradication programme of diseases widely spread following early imports of breeding animals:			
1934-1958	Bovine tuberculosis	Cattle	1937; macroscopic lesions in 30 % of slaughtered cattle (indicating 60-70 % being infected)
1944-1962	Bovine brucellosis	Cattle	1944; 16 000 (6 %) cattle herds infected

Table 1. Significant outbreaks of major epizootic diseases in Sweden for 1900–2020. Adapted from [3].

Authors' note

Professor Stuart Levy, the founder of APUA, had a great commitment for the use of antimicrobials in animals and was a key person when WHO in 1997/98 recommended to phase out the use of antibiotics for growth promotion. Professor Levy during the years acknowledged data and experiences from Sweden and it is therefore a privilege to present these data in the APUA newsletter.