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# Analysis of the distribution of veterinary antimicrobial products to veterinarians in Germany in 2011 and 2012

## *Auswertung der Abgabemengen veterinärmedizinischer Antibiotika an Tierärzte in Deutschland 2011 und 2012*

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**Summary**

For the implementation of risk management measures against the development and spread of antimicrobial resistances it is important to gain a quantitative insight into the use of veterinary antimicrobial agents. Since 2011, all pharmaceutical companies and wholesalers in Germany are required to report their sales data of veterinary antimicrobial products (VAPs). In 2011, 1706 t of antimicrobially active substances were sold to veterinarians registered in Germany, in 2012 the amount decreased to 1619 t. Tetracyclines and penicillins had the largest shares in both years, followed by sulfonamides, macrolides and polypeptides. Amoxicillin alone accounted for more than a quarter of the total amounts of all sold antimicrobials. In regard to AMR it is most important to limit the use of critically important antimicrobials, namely fluoroquinolones and 3$^{rd}$ and 4$^{th}$ generation cephalosporins. While in both years these groups accounted for less than 1% of the amount of sold antimicrobials, this does not reflect adequately their use, since they are used in much lower doses. Furthermore, it is worrying that the sales of fluoroquinolones and 3$^{rd}$ generation cephalosporins increased by 26% and 14%, respectively, between 2011 and 2012, while the sales of 4$^{th}$ generation cephalosporins decreased only by 2%. More than 95% of the active substances were contained in VAPs intended for oral application; only fluoroquinolones, 3$^{rd}$ and 4$^{th}$ generation cephalosporins as well as fenicols were primarily or even exclusively applied by injection.

**Keywords:** antibiotics, consumption, animals, drug monitoring, critically important antimicrobials

**Zusammenfassung**

Um Maßnahmen für das Risikomanagement gegen die Entwicklung und Ausbreitung von Antibiotikaresistenzen zu ergreifen, sind u. a. auch Kenntnisse über die Mengen angewandter Antibiotika in der Veterinärmedizin notwendig. Seit 2011 müssen alle pharmazeutischen Unternehmen und Großhändler in Deutschland ihre Abgabemengen an veterinärmedizinischen Antibiotika an Tierärzte melden. Im Jahr 2011 wurden 1706 t antibiotisch wirksamer Substanzen an Tierärzte in Deutschland abgegeben, 2012 war es eine Menge von 1619 t. Tetracycline und Penicilline hatten in beiden Jahren den größten Anteil, gefolgt von Sulfonamiden, Makroliden und Polypeptiden. Ein Viertel der gesamten Menge entfiel dabei alleine auf Amoxicillin. Im Hinblick auf die Antibiotikaresistenz ist es besonders wichtig, den Einsatz der "critically important antimicrobials", vor allem Fluorchinolone und Cephalosporine der 3. und 4. Generation, zu minimieren. Der Anteil dieser Klassen lag in beiden Jahren unter 1 % der Gesamtabgabemengen. Dies spiegelt jedoch nur unzureichend ihren Einsatz wider, da sie in wesentlich geringerer Dosierung eingesetzt werden als ältere Wirkstoffe. Außerdem ist es durchaus interessant, dass die Abgabemengen von Fluorchinolonen und Cephalosporinen der 3. Generation zwischen 2011 und 2012 um 26 % bzw. 14 %

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zunahmen, während die Abgabemengen von Cephalosporinen der 4. Generation nur um 2 % abnahmen. Mehr als 95 % der Wirkstoffe wurden in Präparaten für die orale Applikation abgegeben, nur Fluorchinolone und Cephalosporine der 3. und 4. Generation sowie Fenicole waren überwiegend oder ausschließlich in Präparaten zur parenteralen Verabreichung enthalten.

**Schlüsselwörter:** Antibiotika, Verbrauch, Tiere, Arzneimittelüberwachung, critically important antimicrobials

## Introduction

Antimicrobials are important tools in the fight against infectious diseases. However, bacteria have developed various mechanisms to avoid the antimicrobial effects, and many of these mechanisms can be transferred from one bacterium to another (Davies and Davies, 2010). Each use of antimicrobials accelerates the development and the spread of antimicrobial resistances and favours the growth of bacteria that are already resistant, which makes the use of antimicrobials ineffective and finally poses a serious risk for public health (Schwarz and Chaslus-Dancla, 2001; da Costa et al., 2013). Especially the application of antimicrobials in food producing animals has come under close scrutiny with regard to human health aspects like the possibility of resistant bacteria entering the food chain.

In order to implement risk management measures it is important to gain a better quantitative insight into the use of veterinary antimicrobial agents (Aarestrup, 1999; Nicholls et al., 2001). Consequently international organisations like the WHO and the EU have recommended monitoring the use of antimicrobials (Anonymous, 2004; European Council, 2012; European Medicines Agency, 2013).

Since 2011, all pharmaceutical companies and wholesalers in Germany are obliged to report their sales data of veterinary antimicrobial products (VAPs) to the German Institute of Medical Documentation and Information (Deutsches Institut für Medizinische Dokumentation und Information, DIMDI) (Anonymous, 2010a). DIMDI processes these data and provides the Federal Office of Consumer Protection and Food Safety (Bundesamt für Verbraucherschutz und Lebensmittelsicherheit, BVL) and the competent Authorities of the Länder for Veterinary Health protection in Germany with the data. Based on these figures the sales data of VAPs in Germany adjusted to the active moiety is now reported for the years 2011 and 2012.

## Material and Methods

### Data collection

Collection of sales data is based on national law (Anonymous, 2010a). All pharmaceutical companies and wholesalers selling VAPs with antimicrobial agents directly to veterinarians residing in Germany are obliged to report annually the total quantity of distributed VAPs to the central portal of the national federal authorities PharmNet.Bund. Lists of VAPs and antimicrobial substances are published and regularly updated (Anonymous, 2012). VAPs are to be specified by the reported year and the national marketing authorisation number (ZNR). Either information regarding the total amount of the VAP or the quantity of delivered packages including a specific package size factor as well as the first two digits of the zip code of the supplied veterinarian is mandatory. Medicated premixes are not included as feed mills are not required to report. Also, the supply chain via retail pharmacies is not in scope of the legal requirements.

### Data processing

Based on the ZNR and the substance identification number (ASK) additional data were imported from the drug information system of the German Higher Federal Authorities (Arzneimittelinformationssystem des Bundes, AMIS). These included brand name, pharmaceutical form, route of administration, Anatomical Therapeutic Chemical (ATC) vet code, target species, active substance(s) and strength(s), reference quantity (e. g. one tablet), package size expressed as a multiple of the reference quantity (e. g. 100 tablets) and strength of active substance per reference quantity (e. g. 5 mg/tablet). From these data the amount of the active substance(s) sold was calculated by the following formula:

$$A_{AS} = PS \times S_{AS/R} \times \sum delivered\ packages$$

$A_{AS}$ = amount of active substance, PS = package size, $S_{AS/R}$ = strength of active substance per reference quantity

Reported and generated data were validated according to formal aspects such as data of the registered companies and the correct use of marketing authorisation number, packing sizes or postal code area and by content-related issues like accordance with sales data from periodic safety update reports of marketed drugs.

If the pharmaceutical presentation in a formulation was not the active moiety, the quantity of the active moiety was calculated by the following formula based on the molecular weight according to the Pharmacopoea Europaea (Anonymous, 2011a).

$$A_{AM} = A_{PP} \times M_{AS} / M_{PP}$$

$A_{AM}$ = amount of active moiety, $A_{PP}$ = amount of pharmaceutical presentation, $M_{AS}$ = molar mass of active moiety, $M_{PP}$ = molar mass of pharmaceutical presentation

## Results

### Quantities sold

In 2011, 38 pharmaceutical companies and 16 wholesalers reported data on sales of 520 VAPs, in 2012, 37 pharmaceutical companies and 19 wholesalers reported data on sales of 553 VAPs. These VAPs contained 67 different antimicrobial substances. In 2011, 434 VAPs (83.5%)

contained one active substance, 82 VAPs (15.8%) contained two, and four VAPs (0.8%) contained three active substances. In 2012, 465 VAPs (84.1%) contained one active substance, 84 VAPs (15.2%) contained two, and 4 VAPs (0.7%) contained three active substances. All VAPs with three active substances were intended for intramammary treatment of dairy cows.

In 2011, 1706 t of antimicrobial active substances were sold to veterinarians registered in Germany, in 2012 the amount decreased to 1619 t. With regard to antimicrobial classes, tetracyclines and penicillins had the largest shares in both years, followed by sulfonamides, macrolides and polypeptides (Tab. 1). Fluoroquinolones and 3rd and 4th generation cephalosporins together, which are listed as critically important antimicrobials (World Health Organisation, 2011) accounted for less than 1% of the total amounts. Compared to 2011, sales of macrolides, aminoglycosides, antifolates, sulfonamides and nitrofuranes decreased by more than 10%, while sales of 3rd generation cephalosporines, fluoroquinolones and pleuromutilines increased by more than 10%. Sales of 1st generation cephalosporins increased more than 20fold compared to the previous year (Tab. 1).

Amoxicillin accounted for more than a quarter of the total amounts of all sold antimicrobials, the largest share of all substances. Other substances which accounted for more than 5% of the total amounts were tetracycline, tylosin, chlortetracycline, sulfadiazine, colistin and doxycycline. Compared to 2011, sales of ampicillin, tetracycline, neomycin, tylosin, sulfadiazine, chlortetracycline and trimethoprim decreased by more than 10%, while sales of tiamulin and doxycycline increased more than 10% and the sales of benzylpenicillin more than doubled (Tab. 2).

**TABLE 1:** *Amounts of antimicrobials sold in Germany in 2011 and 2012 summarized according to antimicrobial classes*

| Antimicrobial class | 2011 | 2012 | Difference |
|---|---|---|---|
| Tetracyclines | 564.429[a] (33.1%) | 566.163 (35.0%) | 0.3%[b] |
| Penicillins | 527.939 (31.0%) | 500.762 (30.9%) | –5.1% |
| Sulfonamides | 184.855 (10.8%) | 161.848 (10.0%) | –12.4% |
| Macrolides | 173.137 (10.2%) | 144.677 (8.9%) | –16.4% |
| Polypeptides | 127.357 (7.5%) | 123.493 (7.6%) | –3.0% |
| Aminoglycosides | 47.139 (2.8%) | 40.246 (2.5%) | –14.6% |
| Antifolates | 29.884 (1.8%) | 26.164 (1.6%) | –12.4% |
| Lincosamides | 16.809 (1.0%) | 15.389 (1.0%) | –8.4% |
| Pleuromutilins | 14.101 (0.8%) | 18.362 (1.1%) | 30.2% |
| Fluoroquinolones | 8.247 (0.5%) | 10.382 (0.6%) | 25.9% |
| Fenicoles | 6.119 (0.4%) | 5.704 (0.4%) | –6.8% |
| 1st generation cephalosporins | 0.130 (0.0%) | 0.139 (0.0%) | 7% |
| 3rd generation cephalosporins | 2.057 (0.1%) | 2.346 (0.1%) | 14.0% |
| 2nd generation cephalosporins | 1.900 (0.1%) | 1.915 (0.1%) | 0.8% |
| 4th generation cephalosporins | 1.427 (0.1%) | 1.399 (0.1%) | –1.9% |
| Nitroimidazoles | 0.111 (0.0%) | 0.102 (0.0%) | –8.5% |
| Nitrofurans | 0.007 (0.0%) | 0.006 (0.0%) | –11.3% |
| Fusidic acid | 0.005 (0.0%) | 0.005 (0.0%) | 1.3% |
| Total | 1705.660 | 1619.041 | –5.1% |

[a] amount of pure substances in metric tonnes
[b] difference in percent of sales in 2011

**TABLE 2:** *Amounts of the most important antimicrobial substances sold in Germany in 2011 and 2012*

| Antimicrobial substance | 2011 | 2012 | Difference |
|---|---|---|---|
| Amoxicillin | 469.075[a] (27.5%) | 436.822 (27.0%) | –6.9%[b] |
| Tetracycline | 300.235 (17.6%) | 226.166 (14.0%) | –24.7% |
| Doxycycline | 104.021 (6.1%) | 192.092 (11.9%) | 84.7% |
| Tylosin | 164.771 (9.7%) | 137.320 (8.5%) | –16.7% |
| Chlortetracycline | 155.865 (9.1%) | 133.077 (8.2%) | –14.6% |
| Colistin | 127.337 (7.5%) | 123.474 (7.6%) | –3.0% |
| Sulfadiazine | 134.519 (7.9%) | 112.471 (6.9%) | –16.4% |
| Benzylpenicillin | 17.477 (1.0%) | 40.956 (2.5%) | 134.3% |
| Trimethoprim | 29.884 (1.8%) | 26.164 (1.6%) | –12.4% |
| Neomycin | 31.868 (1.9%) | 24.797 (1.5%) | –22.2% |
| Sulfadimidine | 26.546 (1.6%) | 24.721 (1.5%) | –6.9% |
| Tiamulin | 14.101 (0.8%) | 18.362 (1.1%) | 30.2% |
| Ampicillin | 32.321 (1.9%) | 17.319 (1.1%) | –46.4% |
| Lincomycin | 16.574 (1.0%) | 15.164 (0.9%) | –8.5% |
| Others | 81.864 (4.8%) | 90.919 (5.6%) | 11.2% |
| Total | 1705.669 | 1619.041 | –5.1% |

[a] amount of pure substance in metric tonnes
[b] difference in percent of sales in 2011

**Pharmaceutical forms**

More than 95% of active substances were distributed in VAPs intended for oral application, mostly as powders. The second highest amount of active substances was distributed in injectable preparations. About 1% of active substances were contained in VAPs for intramammary or intrauterine application or in other pharmaceutical forms, e.g. as sprays or ointments (Tab. 3). While the amount of active substances intended for oral administration decreased in 2012 compared to 2011, the amount of active substances in VAPs intended for the other routes of administration increased.

The highest amounts of most antimicrobial classes were for oral administration. Exceptions were 3rd and 4th generation cephalosporins, fenicols and fluoroquinolones which were primarily or even exclusively applied by injection. Changes in routes of administration between 2011 and 2012 were minor (Tab. 4).

Most commonly orally applied antimicrobial classes were tetracyclines, penicillins, sulfonamides, macrolides and polypeptides, reflecting their share overall. Members of other classes accounted only for 4%. There was a higher diversity of different antimicrobial classes intended for parenteral application. The most important classes here were penicillins, followed by macrolides, aminoglycosides, fenicols, fluoroquinolones and sulfonamides. Other classes had a share of 5% or less. Pastes or suspensions for direct administration into the udder mostly contained penicillins or aminoglycosides, while VAPs for intrauterine application contained tetracyclines, penicillins and 1st and 2nd generation cephalosporins. More than two thirds of those were tetracyclines (Tab. 5).

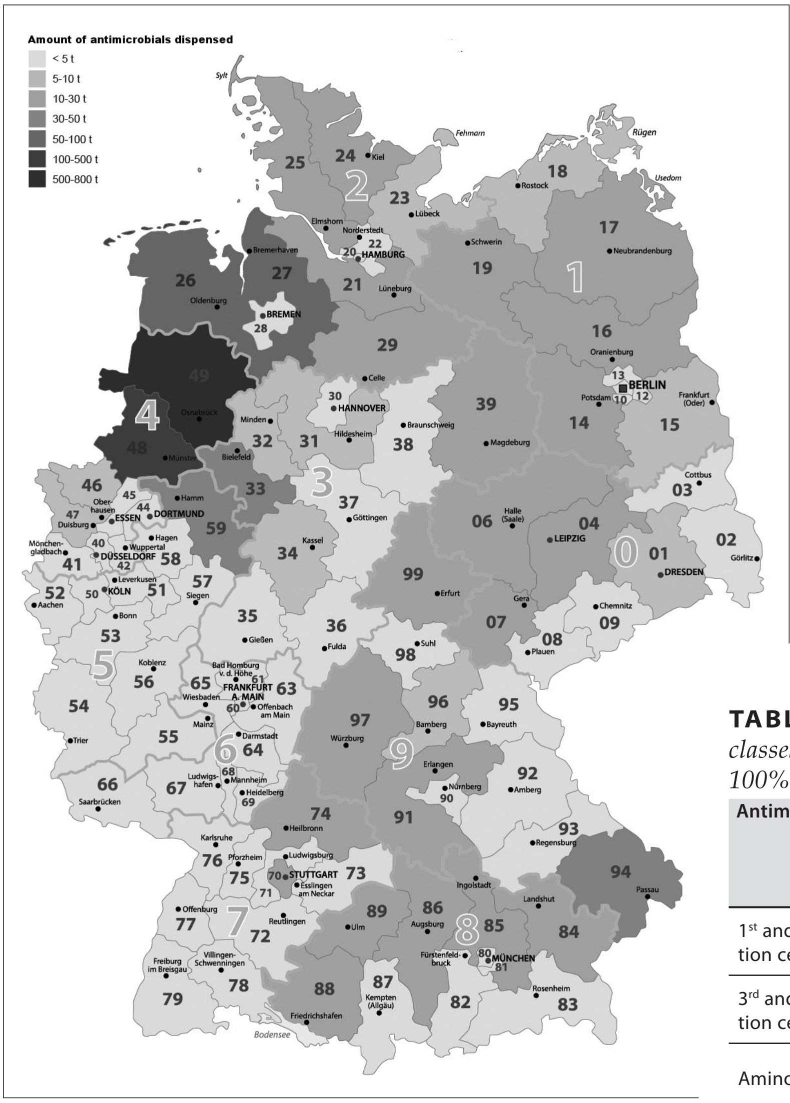


**FIGURE 1:** *Regionalised presentation of the amounts of antimicrobials sold in Germany in 2011 and 2012 based on first two digits of the zip code.*

**TABLE 3:** *Amounts of antimicrobials sold in Germany in 2011 and 2012 according to intended route of administration*

| Intended for | 2011 | 2012 |
|---|---|---|
| Oral application | 1.631.667[a] (95.7%) | 1.541.579 (95.2%) |
| Parenteral application | 54.912 (3.2%) | 56.630 (3.5%) |
| Intramammary application | 12.011 (0.7%) | 12.676 (0.8%) |
| Intrauterine application | 3.786 (0.2%) | 5.023 (0.3%) |
| Other application | 3.273 (0.2%) | 3.401 (0.2%) |
| Total | 1705.660 | 1619.039[b] |

[a] amount of pure substances in tonnes
[b] differs from the amounts given in Tables 1 and 2 due to rounding

**TABLE 4:** *Intended route of administration of antimicrobial classes sold in Germany in 2011 and 2012. Sums may differ form 100% due to rounding*

| Antimicrobial class | Year | Intended route of application | | | | |
|---|---|---|---|---|---|---|
| | | Oral | Parenteral | Intramammary | Intrauterine | Other |
| 1st and 2nd generation cephalosporins | 2011 | 79.6%[a] | –[b] | 17.4% | 3.0% | – |
| | 2012 | 78.6% | – | 18.2% | 3.2% | – |
| 3rd and 4th generation cephalosporins | 2011 | – | 82.6% | 17.4% | – | – |
| | 2012 | – | 83.4% | 16.6% | – | – |
| Aminoglycosides | 2011 | 81.6% | 12.6% | 5.5% | – | 0.2% |
| | 2012 | 78.3% | 14.9% | 6.5% | – | 0.2% |
| Antifolates | 2011 | 96.2% | 3.8% | – | – | – |
| | 2012 | 95.6% | 4.4% | – | – | – |
| Fenicols | 2011 | 20.6% | 77.2% | – | – | 2.2% |
| | 2012 | 19.5% | 75.6% | – | – | 5.0% |
| Fluoroquinolones | 2011 | 44.3% | 55.6% | – | – | 0.1% |
| | 2012 | 47.9% | 52.0% | – | – | 0.1% |
| Lincosamides | 2011 | 91.2% | 7.4% | 1.5% | – | – |
| | 2012 | 91.2% | 7.6% | 1.2% | – | – |
| Macrolides | 2011 | 97.4% | 2.6% | – | – | – |
| | 2012 | 97.1% | 2.9% | – | – | – |
| Penicillins | 2011 | 94.2% | 4.1% | 1.5% | 0.2% | – |
| | 2012 | 93.6% | 4.4% | 1.8% | 0.2% | – |
| Pleuromutilins | 2011 | 99.2% | 0.8% | – | – | – |
| | 2012 | 99.5% | 0.5% | – | – | – |
| Polypeptides | 2011 | 100% | – | – | – | – |
| | 2012 | 100% | – | – | – | – |
| Sulfonamides | 2011 | 95.8% | 3.2% | – | – | 1.0% |
| | 2012 | 95.0% | 3.9% | – | – | 1.1% |
| Tetracyclines | 2011 | 98.9% | 0.4% | – | 0.5% | 0.2% |
| | 2012 | 98.6% | 0.5% | – | 0.7% | 0.2% |
| Other | 2011 | 89.6% | 9.8% | – | – | 0.5% |
| | 2012 | 89.8% | 9.6% | – | – | 0.6% |

[a] percent of the amount sold of this class
[b] no product containing an antimicrobial substance of this class for this route of application

### Regionalised analysis

A regionalised presentation of the sales data of VAPs in Germany 2012 based on the first two digits of the zip code is given in Figure 1. Almost 50% of the active substances were delivered to veterinarians in the postal code area 48 and 49 in the western part of Lower Saxony and the northern part of North Rhine-Westphalia. There were no significant differences in comparison with 2011.

## Discussion

In order to monitor the developments in the use of antibiotics, the amount of VAPs sold from pharmaceutical companies and wholesalers to veterinarians in Germany has to be reported since 2011 (Anonymous, 2010a). The current report presents the sales data of VAPs in Germany for the first two years. In Germany veterinary surgeries are allowed to sell VAPs directly to the animal owners after clinical inspection of the animals and if certain other conditions are met (Anonymous, 2005). Therefore, very few VAPs are purchased by owners via other routes, e. g. from pharmacies. Thus, the amounts of antimicrobials sold to veterinarians can be assumed to correlate to the amounts of antimicrobials actually used for the treatment of animals in Germany. Differences to the current use of antimicrobials in animals are

**TABLE 5:** *Proportion of antimicrobial classes sold in Germany in 2011 and 2012 according to intended route of application. Sums may differ form 100% due to rounding*

| Antimicrobial class | Intended route of application | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Oral | | Parenteral | | Intramammary | | Intrauterine | | Other | |
| | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 |
| 1st and 2nd gen. cephalosporins | 0.1%[a] | 0.1% | –[b] | – | 2.9% | 3.0% | 1.6% | 1.3% | – | – |
| 3rd and 4th gen. cephalosporins | – | – | 5.2% | 5.5% | 5.0% | 4.9% | – | – | – | – |
| Aminoglycosides | 2.4% | 2.1% | 10.8% | 10.7% | 21.8% | 20.8% | – | – | 3.0% | 2.8% |
| Antifolates | 1.8% | 1.6% | 2.0% | 2.0% | 0.1% | 0.1% | – | – | – | – |
| Fenicols | 0.1% | 0.1% | 8.6% | 7.6% | – | – | – | – | 4.0% | 8.3% |
| Fluoroquinolones | 0.2% | 0.3% | 8.3% | 9.6% | – | – | – | – | 0.3% | 0.4% |
| Lincosamides | 0.9% | 0.9% | 2.3% | 2.0% | 2.1% | 1.5% | – | – | – | – |
| Macrolides | 10.3% | 9.1% | 8.2% | 7.3% | 0.1% | 0.1% | – | – | – | – |
| Penicillins | 30.5% | 30.4% | 38.9% | 38.9% | 68.0% | 69.7% | 26.7% | 20.9% | 0.3% | 0.3% |
| Pleuromutilins | 0.9% | 1.2% | 0.2% | 0.2% | – | – | – | – | – | – |
| Polypeptides | 7.8% | 8.0% | – | – | – | – | – | – | 0.1% | 0.1% |
| Sulfonamides | 10.8% | 10:% | 10.9% | 11.3% | – | – | – | – | 55.6% | 50.5% |
| Tetracyclines | 34.2% | 36.2% | 4.4% | 4.7% | – | – | 71.6% | 77.8% | 36.7% | 37.4% |
| Others | 0.1% | 0.1% | 0.2% | 0.2% | – | – | – | – | 0.2% | 0.2% |

[a] percent of the amount of all antimicrobial substances in products intended for this route of application
[b] no product containing an antimicrobial substance of this class for this route of application

**TABLE 6:** *Population of the most important animal species in Germany 2011 and 2012 according to the Bundesverband für Tiergesundheit (BfT) 2014*

| Species and production type | 2011 | 2012 | Difference |
|---|---|---|---|
| Cattle (total) | 12.5[a] | 12.5 | 0[b] |
| Dairy cows | 4.2 | 4.2 | 0 |
| Pigs (total) | 27.4 | 28.3 | 3.3 |
| Breeding sows | 2.2 | 2.1 | -4.6 |
| Sheep (total) | 1.7 | 1.6 | -5.9 |
| Breeding sheep | 1.2 | 1.2 | 0 |
| Broilers (placements) | 765.0 | 743.8 | -2.8 |
| Laying hens | 34.0 | 36.6 | 7.6 |
| Dogs | 5.3 | 5.4 | 1.9 |
| Cats | 8.2 | 8.2 | 0 |
| Horses | 1.0 | 1.0 | 0 |

[a] number in millions
[b] difference in percent of 2011

due to pre-mixes sold to feed mills and by the disposal of unused products. Furthermore it is unknown to which extent VAPs sold to veterinary surgeries in Germany are given to animals in other member states and vice versa.

The analysis according to regions showed that the highest amounts of antimicrobial substances were sold to veterinarians residing in areas with high densities of livestock. In these areas, also some large veterinary surgeries are located which operate in much wider regions and even in other federal states of Germany. Thus, the actual use of antimicrobial substances in these specific regions will most likely be lower than the sales data displayed for these regions in Figure 1. On the other hand, low sales data in other regions do not necessarily imply low actual use of antimicrobials.

Since most of the VAPs are approved for use in two or more species, it is not possible to estimate the species specific use of VAPs from these data. In regions with high densities of livestock, usually all types of livestock are kept in high numbers. Thus it is not possible to draw reliable conclusions from the regional distribution of sales regarding the target animal species. Furthermore, only the weight of the sold compounds is known. Since there are no widely accepted Defined Daily Doses Animals (DDDA) and Defined Course Doses Animals (DCDA) comprising all animal species as they have been set for human medicine, the amounts allow no conclusion on the dosage and on the frequency with which each antimicrobial was prescribed. These limitations are inherent to the data collection method set by the law, which had to take into account the short term feasibility for a large country like Germany.

Monitoring a more specific use of VAPs would require collecting data on the level of veterinary surgeries or farms. In the frame of the "VetCAb" project a pilot study and a feasibility study collected data on the use of VAPs in Germany from a small sample of veterinary surgeries and farms which voluntarily participated in the study (van Rennings et al., 2014). However, in the VetCAb project only data on the use of antimicrobials in selected production levels of poultry, pigs, and cattle were included, so information on the use in horses, companion animals and minor species are missing.

In the present study and in the VetCAb project tetracyclines and penicillins were the most common antimicrobial classes with some differences between the species included in the study. Differences between observed and estimated shares were up to 5% (van Rennings et al., 2014, Tab. 4). The differences might be caused by the use of different antimicrobial classes in the production levels and species not included in the VetCAb project. Furthermore, the sample investigated in the VetCAb project might not have been fully representative due to regional differences and the limitation to the inclusion of only voluntarily participating surgeries and farms.

A report on the use of antibiotics in broilers, meat turkeys, fattening pigs and fattening calves in the state Lower Saxony showed similar trends in regard to the use of different antimicrobial classes. However, comparison of the data is difficult, since this regional report gives the number of treatments during the fattening period and not the amount of used antimicrobials (Anonymous, 2011b).

The discrepancies between the total sales data and the studies based on samples show that not taking into account all animal species and investigating only a small sample can lead to a wrong picture of the use of antimicrobials in animals. An official system monitoring the use of antimicrobials in meat producing animals will be implemented in the near future (Anonymous, 2005, 2013).

In regard to antimicrobial resistances it is most important to limit the use of the critically important antimicrobials, namely fluoroquinolones and 3rd and 4th generation cephalosporins. While in both years they accounted for less than 1% of the amount of sold antimicrobials, this does not adequately reflect their use. The potency of antimicrobial agents can differ considerably resulting in lower dosages of fluoroquinolones and 3rd and 4th generation cephalosporins. Additionally the dosage may also vary between the different animal species. Furthermore it is worrying that the sales of fluoroquinolones and 3rd generation cephalosporins increased by 26% and 14%, respectively, between 2011 and 2012, while the sales of 4th generation cephalosporins decreased only by 2%. Third and fourth generation cephalosporins were only contained in VAPs for parenteral or intramammary application, while almost 50% of fluoroquinolones were sold in VAPs for oral application, the least desirable application form with regard to the development of antimicrobial resistances. Oral application is more unreliable than parenteral application and is supposed to cause a rapid shedding of resistant bacteria in the feces (Wiuff et al., 2003; Zhang et al., 2013).

In this context, it is also regrettable, that 95% of all antimicrobial substances were contained in VAPs for oral administration. The reason is the apparent ease of the oral application of any pharmaceutical products to animals. Furthermore, large numbers of animals, especially on poultry farms, make any other route of application nearly impossible.

The total sales of antimicrobials decreased by 5.1% between 2011 and 2012. Apparently this was not caused by a decline in the animal population. Compared to 2011, there were 4.6% less breeding sows, 5.9% less sheep and 2.8% less broiler placements in Germany, while the numbers of pigs in total and laying hens increased 3.3% and 7.6%, respectively. The numbers of other species and production types remained more or less unchanged (Tab. 6; Bundesverband für Tiergesundheit, 2014).

In conclusion the data show some apparently positive results like the reduction of the total amount of antimicrobials sold. However, this might also be due to an increased use of compounds given at lower doses or of longer acting compounds. There are also some negative aspects, like an increased use of critically important antimicrobials in animals and the predominantly oral application of VAPs.

Thus the recorded figures give some indications, which steps can be taken to reduce antimicrobial resistances in bacteria in and on animals. If antimicrobials are used, this has to be done in a responsible and deliberate way, e.g. according to the current German guidelines on the use of antimicrobials in animals (Anonymous, 2010b). Exclusively setting quantitative targets for the reduction of the use of antibiotics will not be sufficient or successful.

## Conflict of interest

The corresponding author confirms that there are no conflicts of interest regarding the preparation of the manuscript.

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