2 Scottish Antimicrobial Prescribing Group. *Guidance to Reduce Multi-Drug Resistant Gram Negative Bacteria (MDRGNB) Infections*. 2013. http://www.scottishmedicines.org.uk/files/sapg/SAPG_Guidance_to_reduce_MDRGNB_October_2013.pdf.

3 *Aztreonam – Summary of Product Characteristics. Azactam 1g or 2g Powder for Solution for Injection or Infusion, Vial*. Bristol-Myers Squibb, UK.

4 Brogden RN, Heel RC. Aztreonam. A review of its antibacterial activity, pharmacokinetic properties and therapeutic use. *Drugs* 1986; **31**: 96–130.

5 Livermore D. Minimising antibiotic resistance. *Lancet Infect Dis* 2005; **5**: 450–9.

6 Livermore D. Of stewardship, motherhood and apple pie. *Int J Antimicrob Agents* 2014; **43**: 319–22.

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Antimicrobial prescription patterns of veterinarians: introduction of a benchmarking approach

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Sir,

For every antibiotic or antimicrobial agent developed, bacteria will ultimately develop resistance, leading to treatment failure in animals and humans.[1] Implementation of surveillance systems is crucial to monitor usage and reduce public health risks.[2] Several European countries closely monitor human as well as veterinary use (sector and farm levels).[3,4] In the Netherlands, farmers and veterinarians have a common responsibility for use of antimicrobials on farms. A benchmark indicator for antimicrobial use on farms was defined and introduced earlier. Here, we describe the benchmarking approach for veterinarians that was recently introduced.

Over the last decade, the Netherlands consistently showed one of the lowest use figures in human medicine compared with other European countries. These figures were in contrast to the high use in livestock production.[5] Therefore, and driven by the emergence of antimicrobial-resistant bacteria in livestock, such as MRSA and ESBL-producing Enterobacteriaceae, goals of 50% and 70% reduction of veterinary antimicrobial sales were set by the government, relative to sales in 2009, to be achieved in 2013 and 2015, respectively.[6,7] In order to achieve this goal, benchmark thresholds for veterinary antimicrobial use on individual livestock farms were decided upon in 2011 by the Netherlands Veterinary Medicines Authority (SDa).[4] So far, benchmark thresholds have been set for the four major livestock sectors, comprising ~42 500 veal calf, pig, broiler and cattle farms, based on the distribution of antimicrobial use on all farms in a certain livestock subsector (e.g. dairy cattle, finisher pigs). With a few exceptions (e.g. the cattle sector, because of its low antimicrobial usage), these benchmark thresholds were pragmatically based on the 50th and 75th percentiles of the distribution of defined daily dosages animal per farm ($DDDA_F$) in a sector to define signal and action categories, respectively.[4]

$DDDA_F$ facilitates categorizing farms into benchmark categories, of which the action category reflects the highest usage. As established by law, each farm is linked to one specific veterinarian (the contracted veterinarian), and therefore analysis can be done for all farms served by one veterinarian.

After setting benchmark thresholds for farm-level use, the SDa aimed at transparency of prescription patterns of veterinarians. Benchmarking prescription patterns of veterinarians enables: (i) evaluation of systematic differences in patterns between veterinarians; (ii) veterinarians to compare their prescription pattern with those of colleagues; and (iii) farmers to make well-considered choices of veterinarians they want to contract.

The SDa defined three criteria the benchmarking indicator should take into account: (i) that one veterinarian usually is the contracted veterinarian for several livestock farms; (ii) the extent to which use on one farm deviates from the average farm level use; and (iii) sensitivity to differences in use between the farms for which the veterinarian is responsible.[8]

On the basis of these criteria, a measure was defined that estimates for each veterinarian the likelihood of having farms under their responsibility that exceed the action benchmark threshold. A detailed rationale and description of how this parameter has to be calculated can be found in the Supplementary data (available at *JAC* Online). The benchmark indicator for veterinarians estimates the likelihood of exceeding the farm action benchmark threshold for all farms for which the veterinarian is the contracted veterinarian. Data on antimicrobials delivered in 2012 by veterinarians to all Dutch livestock farms were used to calculate antimicrobial use per farm and per veterinarian.

The likelihood of exceeding the action threshold shows large variation in prescription patterns between veterinarians (Figure 1). The likelihood of exceeding the action threshold ranged from 0 (no farms above the action benchmark value) to 0.99 (virtually all farms above the action benchmark value). The lowest values were found for veterinarians in the cattle sector and the highest were found for veterinarians in the veal calf sector. Other sectors had intermediate values. The results show a right-tailed distribution, with mean/median values ranging from 0.12/0.11 (cattle

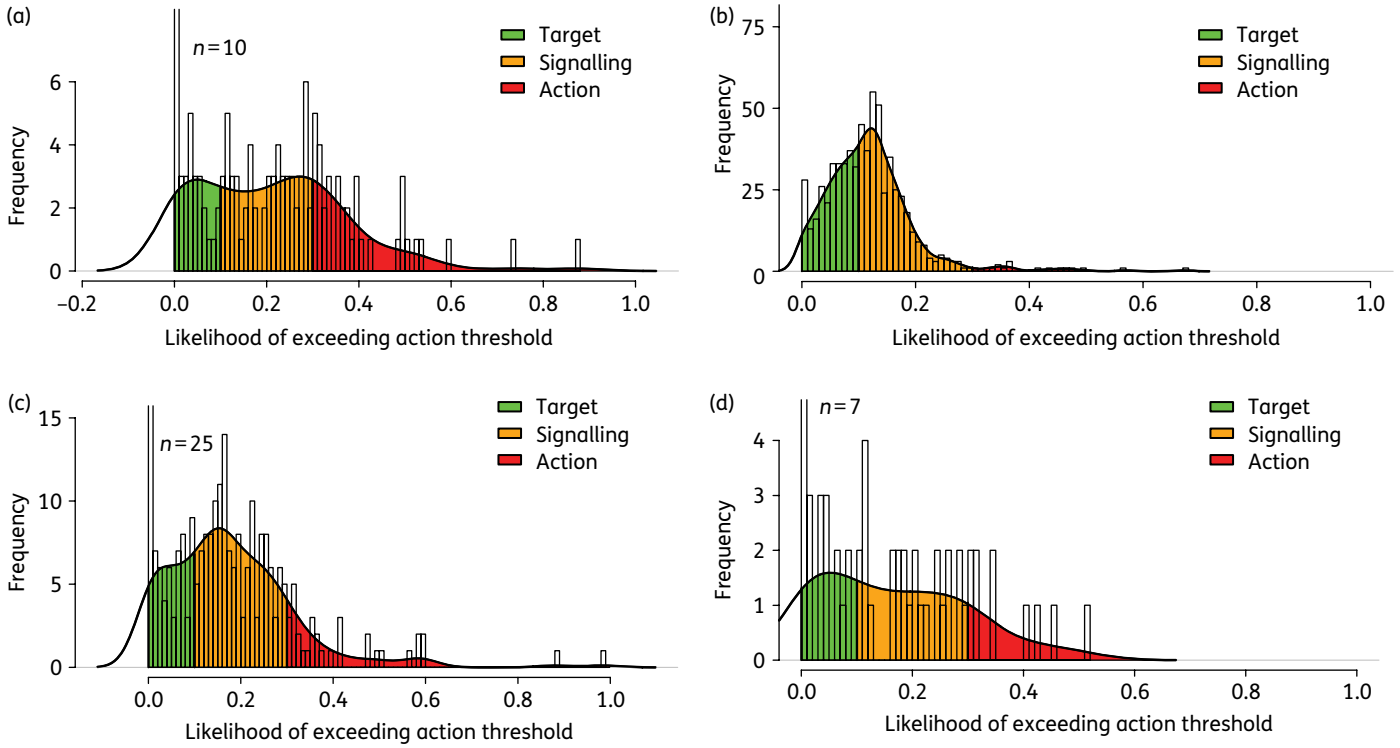

Figure 1. Distribution of the veterinary benchmark indicator for 2012, which describes the likelihood of exceeding the action threshold per veterinarian for the different livestock sectors [veal calves (a), cattle (b), pigs (c) and broilers (d)]. This figure appears in colour in the online version of *JAC* and in black and white in the print version of *JAC*.

sector) to 0.21/0.21 (veal calf sector), and the pig sector (0.18/0.16) and broiler sector (0.17/0.16) showing similar values.

The action benchmark threshold for veterinarians has been arbitrarily set at 0.30 by the Expert Panel of the SDa. This value can intuitively be interpreted as equivalent to 'on one out of three farms more antimicrobials are used than the action threshold'. Thus, when on more than one out of three farms antimicrobials are used above the action benchmark threshold, the veterinarian has a prescription pattern that requires direct action. For communication purposes, this is a convenient way of describing the value of the benchmark threshold, but, theoretically, a value >0.30 can be obtained with fewer than ~30% of the farms in the action zone. The target benchmark threshold for veterinarians has been set at 0.10. In general, the system hinges on the benchmark values decided for each farm sector. At present these benchmark values are pragmatic values. It is desirable to be able to set benchmark thresholds based on measurable risk of antimicrobial resistance occurrence, i.e. the maximum quantity of antimicrobials that can be consumed where the level of development of antimicrobial resistance is considered manageable. So far no scientific basis is available for underpinning such a quantity.

The approach taken is unique in the sense that few studies have attempted to develop benchmarking antimicrobial prescriptions, even in human medicine.[9,10] The added value of setting benchmarks for veterinarians is first and foremost to be found in self-regulation of the veterinarians, as the benchmark threshold is expected to stimulate veterinarians to mirror their prescription pattern to their colleagues and to trigger discussions between veterinarians. These discussions should lead to reflection and feedback on prescription patterns within veterinary practices and within the veterinary sector, but also between farmers and veterinarians. Furthermore, by making prescription patterns transparent, farmers can eventually make informed decisions regarding the veterinarian who they will contract. Veterinarians are provided with access to an online tool that they can use to calculate their veterinary benchmark indicator, thus creating transparency in the method.

The veterinary benchmark indicator presented here is a robust indicator that can easily be applied. It is expected that benchmarking of veterinarians will lead to transparent and responsible prescription patterns in veterinary practice.

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Supplementary data

Supplementary data are available at *JAC* Online (http://jac.oxfordjournals.org/).

References

1 Abraham EP, Chain E. An enzyme from bacteria able to destroy penicillin. *1940. Rev Infect Dis* 1988; **10**: 677–8.

2 WHO. *Antimicrobial Resistance—Global Report on Surveillance*. 2014. http://www.who.int/drugresistance/documents/surveillancereport/en/.

3 Danish Integrated Antimicrobial Resistance Monitoring and Research Programme. *DANMAP 2012: Use of Antimicrobial Agents and Occurrence of Antimicrobial Resistance in Bacteria from Food Animals, Food and Humans in Denmark*. Copenhagen, 2013. http://www.danmap.org/~/media/Projekt%20sites/Danmap/DANMAP%20reports/DANMAP%202013/DANMAP%202013.ashx.

4 Bos MEH, Taverne FJ, van Geijlswijk IM *et al*. Consumption of antimicrobials in pigs, veal calves, and broilers in the Netherlands: quantitative results of nationwide collection of data in 2011. *PLoS One* 2013; **8**: e77525.

5 Mevius DJ, Koene MGJ, Wit B *et al*., eds. *MARAN 2013: Monitoring of Antimicrobial Resistance and Antibiotic Usage in Animals in the Netherlands in 2010/2011*. Lelystad, 2012; 43. http://www.wageningenur.nl/upload_mm/f/2/8/39a1adb8-497e-49d6-b696-9401f23089f5_MARAN2012.pdf.

6 Voss A, Loeffen F, Bakker J *et al*. Methicillin-resistant *Staphylococcus aureus* in pig farming. *Emerg Infect Dis* 2005; **11**: 1965–6.

7 Dierikx C, van der Goot J, Fabri T *et al*. Extended-spectrum-β-lactamase- and AmpC-β-lactamase-producing *Escherichia coli* in Dutch broilers and broiler farmers. *J Antimicrob Chemother* 2013; **68**: 60–7.

8 The Netherlands Veterinary Medicines Authority (SDa). *The Veterinary Benchmark Indicator: Towards Transparent and Responsible Antibiotic Prescription Patterns in Veterinary Practice*. Utrecht, 2014. http://www.autoriteitdiergeneesmiddelen.nl/Userfiles/pdf/SDa-rapporten/sda-report-the-veterinaire-benchmark-indicator-(vbi).pdf.

9 Polk RE, Hohmann SF, Medvedev S *et al*. Benchmarking risk-adjusted adult antibacterial drug use in 70 US academic medical center hospitals. *Clin Infect Dis* 2011; **53**: 1100–10.

10 Fitzpatrick RW, Edwards CMC. Evaluation of a tool to benchmark hospital antibiotic prescribing in the United Kingdom. *Pharm World Sci* 2008; **30**: 73–8.