

ORIGINAL ARTICLE

Determinants Associated with Veterinary Antimicrobial Prescribing in Farm Animals in the Netherlands: A Qualitative Study

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Impacts

- Thorough understanding of veterinarians' current prescribing practices and their reasons to prescribe antimicrobials was investigated using qualitative methods.
- Important issues raised by veterinarians concerning antimicrobial prescribing were perceptions of professional responsibilities, risk avoidance, financial dependency on clients and client pressure, farmers' management practices and compliance to veterinary advices, economic aspects hindering disease preventive actions, advisory competencies of veterinarians and personal beliefs on antimicrobial resistance.
- Interventions to change prescribing behavior of farm animal veterinarians could address attitudes and advisory skills of veterinarians, as well as provide tools to deal with (perceived) pressure from farmers and advisors to prescribe antimicrobials.

Keywords:

Antimicrobial resistance; livestock; public health; veterinary medicine; qualitative methods

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Summary

Antimicrobial use in farm animals might contribute to the development of antimicrobial resistance in humans and animals, and there is an urgent need to reduce antimicrobial use in farm animals. Veterinarians are typically responsible for prescribing and overseeing antimicrobial use in animals. A thorough understanding of veterinarians' current prescribing practices and their reasons to prescribe antimicrobials might offer leads for interventions to reduce antimicrobial use in farm animals. This paper presents the results of a qualitative study of factors that influence prescribing behaviour of farm animal veterinarians. Semi-structured interviews with eleven farm animal veterinarians were conducted, which were taped, transcribed and iteratively analysed. This preliminary analysis was further discussed and refined in an expert meeting. A final conceptual model was derived from the analysis and sent to all the respondents for validation. Many conflicting interests are identifiable when it comes to antimicrobial prescribing by farm animal veterinarians. Belief in the professional obligation to alleviate animal suffering, financial dependency on clients, risk avoidance, shortcomings in advisory skills, financial barriers for structural veterinary herd health advisory services, lack of farmers' compliance to veterinary recommendations, public health interests, personal beliefs regarding the veterinary contribution to antimicrobial resistance and major economic powers are all influential determinants in antimicrobial prescribing behaviour of farm animal veterinarians. Interventions to change prescribing behaviour of farm animal veterinarians could address attitudes and advisory skills of veterinarians, as

well as provide tools to deal with (perceived) pressure from farmers and advisors to prescribe antimicrobials. Additional (policy) measures could probably support farm animal veterinarians in acting as a more independent animal health consultant.

Introduction

Livestock industries in industrialized countries are usually well developed and typically use large amounts of antimicrobials (Aarestrup et al., 2008; Angulo et al., 2009). For public health reasons, increasing attention is drawn towards a more prudent and restrictive use of antimicrobials in farm animals (Barza et al., 2002; Codex Alimentarius, 2005; McEwen, 2006; Aarestrup et al., 2008; FAO/WHO/OIE, 2008; Prescott, 2008).

Since 2010, there has been an almost 50% reduction of antimicrobial use in farm animals towards 2013 in the Netherlands (Anonymous, 2010; Speksnijder et al., 2014). Veterinarians in the Netherlands are responsible for prescribing and overseeing the use of antimicrobials in animals and could therefore have a potentially leading role in modifying current practices to reduce antimicrobial use (Morley et al., 2005). A thorough understanding of veterinarians' current prescribing practices, their attitude towards the newly introduced regulations and their perceived barriers and opportunities for adjusting prescribing practices might offer leads for interventions to reduce antimicrobial use in farm animals (Butler et al., 1998; Grol and Wensing, 2004).

Targeting prescribing behaviour of physicians has shown to be effective in reducing antimicrobial use in human health care (Oxman et al., 1995; Welschen et al., 2004; McNulty and Francis, 2010; Butler et al., 2012). Several determinants influence prescribing behaviour of physicians, such as perceived patient pressure to prescribe antimicrobials, risk avoidance and pressure from colleagues (Butler et al., 1998; Kumar et al., 2003; Petursson, 2005; Simpson et al., 2007; Hulscher et al., 2010a,b). These factors along with ones more specifically related to veterinary medicine might be important prescribing determinants for veterinarians. Prescribing behaviour of veterinarians has only sporadically been researched, and comprehensive insights into determinants influencing prescribing behaviour of veterinarians are still lacking (Prescott, 2008; McIntosh et al., 2009; Regula et al., 2009; Jan et al., 2012).

We conducted semi-structured interviews with farm animal veterinarians to identify determinants influencing farm animal veterinarians to prescribe antimicrobials. The reported prescribing determinants can be used, after validation amongst an extended group, to develop feasible interventions aimed at the reduction of antimicrobial prescription in farm animals.

Methods

Instrument development

Qualitative techniques with semi-structured interviews were used to explore reasons for veterinarians to prescribe antimicrobials (Britten, 1995; Pope et al., 2000, 2002; DiCiccio-Bloom and Crabtree, 2006; Collingridge and Gantt, 2008). As prescribing behaviour of veterinarians is currently criticized in the public debate, individual interviews instead of group interviews were preferred to allow respondents to express controversial views. To identify different themes to be explored, a list of potential determinants influencing prescribing behaviour of farm animal veterinarians was constructed using the literature on prescribing behaviour of physicians (Cockburn and Pit, 1997; Butler et al., 1998; Kumar et al., 2003; Petursson, 2005; Hart et al., 2006; Simpson et al., 2007, 2009; Hulscher et al., 2010a,b) and consultations were organized with members of the advisory board of the project which consisted of veterinarians working in academia and board members of the Royal Dutch Veterinary Association (KNMvD).

The perceived roles of other actors like farmers and non-veterinary advisors, the economy, the society and the government were also explored (based on Hulscher et al., 2010b, who describe four levels of relevant groups of prescribing determinants of physicians). An interview guide was developed based on the developed list of potential prescribing determinants (see Appendix I). This interview guide was tested in three pilot interviews with practicing farm animal veterinarians.

Participants

Inclusion criteria for the selection of respondents were (i) at least 2 years practical experience and (ii) full-time working with farm animals. Participants were selected so that they represented veterinarians working in each of the four major livestock sectors (i.e. poultry, swine, veal calves and dairy) and working in different provinces of the country. Some experienced practicing farm animal veterinarians were suggested by members of the advisory board of the project, based on the personal belief that these veterinarians were able to clearly express their professional views and opinions on the role of veterinarians in antimicrobial use in farm animals. Respondents were approached by telephone to participate in an interview. The interviews were

performed by DS, a researcher and practicing farm animal veterinarian. After completion of the interviews, the respondents were asked to suggest other veterinarians from other parts of the country who were expected to hold opposing views in accordance with the snowball method (Wester and Peters, 2004; Onwuegbuzie and Leech, 2007). These veterinarians were then approached to participate in this study, thereby enhancing the collection of various opinions and views (Malterud, 2001; DiCicco-Bloom and Crabtree, 2006; Collingridge and Gantt, 2008).

Data collection and analysis

The interviews (duration 45–79 min) were recorded on tape, transcribed verbatim and analysed using ATLAS.ti (2014) (ATLAS.ti Scientific Software Development GmbH, Berlin). Interviews took place between September 2011 and January 2012. This study was exempt from ethical approval according to Dutch legislation (Law on Medical Scientific Research with People) because no patients were involved. Nevertheless, signed informed consents were obtained from the participants, assuring confidential handling of the data. Concurrently with data collection, transcribed interviews were iteratively analysed. This sequential analysis during data collection made it possible to refine questions, develop hypotheses and pursue emerging themes in more depth during following interviews (Pope et al., 2000; DiCicco-Bloom and Crabtree, 2006; Collingridge and Gantt, 2008). DS reviewed the transcripts inductively. The most important themes in the data on the role of farm animal veterinarians in antimicrobial use were marked with a label, thereby enabling the categorization of the extracted themes based on the assigned labels. These categories were further analysed and refined and subsequently used to create an initial template representing the most important themes based on their mutual relationships (Pope et al., 2000; Wester and Peters, 2004).

AG analysed three of the transcripts independently. These three double-reviewed transcripts were compared to check inter-rater reliability of the analysing process. When doubts existed about the categorization in non-double-reviewed transcripts, AG was consulted for discussion about these text fragments.

After nine interviews, the categorization of themes in the template was critically evaluated in the advisory board of the project and the categorization of these themes in the template was discussed. Regular consultation with all authors took place to discuss whether formerly unmentioned themes emerged in interviews with new respondents to decide when saturation of data was reached. A preliminary report summarizing all the interviews including quotations on which conclusions were based was sent to the respondents for a final check of interpretations of the inter-

Table 1. Characteristics of the respondents

Respondent ID	Animal species of main concern	(Co-)Owner versus payroll	Years of experience
R1	Poultry	(Co-)Owner	33
R2	Poultry	Payroll	8
R3	Veal calves	(Co-)Owner	19
R4	Poultry	(Co-)Owner	15
R5	Pigs	Payroll	10
R6	Dairy/veal calves	(Co-)Owner	26
R7	Dairy	(Co-)Owner	2
R8	Pigs	(Co-)Owner	20
R9	Dairy	(Co-)Owner	22
R10	Pigs	Payroll	17
R11	Veal calves	(Co-)Owner	10

views (Mays and Pope, 2000). Interviews were conducted in Dutch, and analyses of the transcripts were also performed in Dutch. Quotations in this manuscript were translated as if they were originally said in English.

Results

All approached veterinarians accepted to participate in this study, except one due to a lack of time. All veterinarians were working in different group practices from different regions of the country and were specialized in just one or two animal species (Table 1). After eleven interviews, no new themes emerged interviewing was discontinued.

It emerged from the interviews that promoting prudent antimicrobial use in farm animals can roughly be realized at three levels: (i) prevent animal diseases through successful and consistent implementation of preventive measures for diseases; (ii) perform a correct diagnostic process to avoid unnecessary antimicrobial treatment; and (iii) select antimicrobial treatments based on sensitivity of the involved pathogen(s) and pharmacological properties of the antimicrobial, followed by a correct administration of the antimicrobial. The different actors have different roles and influences at these levels which determine the opportunities and barriers that exist at each level to promote prudent use of antimicrobials in farm animals. This is graphically summarized in Fig. 1. These three levels will be separately discussed below.

Prevention of Animal Diseases

Role of veterinarians on farms

All respondents mentioned that in addition to their traditional curative veterinary work, providing veterinary advices to farmers is increasingly part of their daily work. This advice particularly focuses on promoting animal health and welfare and improving production results.

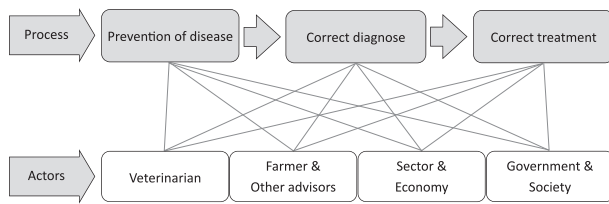


Fig. 1. Different actors are related to veterinary antimicrobial use and reduction of antimicrobial use. Each of these have different interests, are interrelated and influence each other.

Respondent (R)4: 'My role as veterinarian is to work together with the farmer to keep an eye on animal health and everything that is related to that; nutrition, ventilation. Some sort of a management consultant, that is what it is actually.'

Most respondents emphasized the importance of regular farm visits to monitor the actual health of the animals and to identify existing risk factors for animal diseases in order to timely advise farmers to take specific actions to prevent (further dissemination of) animal diseases. The availability of actual and reliable farm performance data is considered an important additional tool to assess whether or not veterinary interventions are required.

Low tariffs for veterinary advisory services were regarded to be essential to remain or get the motivation for farmers to consult veterinarians for regular farm visits and advices. Higher tariffs for veterinary consults is expected to decrease the motivation for farmers for intensive veterinary supervision which might, according to some respondents, eventually result in more animal health problems and associated antimicrobial use.

Some respondents indicated that veterinarians have to improve their knowledge of animal nutrition and housing conditions and how they relate to animal diseases to further improve their advisory role on animal health to farmers. According to other respondents, it is sufficient for a veterinarian to correctly identify problems due to inadequate feed or housing conditions and subsequently call for specialists.

Economic considerations hampering prevention of animal diseases

All respondents mentioned economic considerations as a major driver of decisions made in livestock farming. This was mentioned by all, except dairy veterinarians, to be a substantial cause of antimicrobial use in farm animals.

R4: 'And it is available, eh. . . The "Volwaard"-chicken. A wonderful initiative. We reduce the growth rate of those

broilers and they hardly use any medicines. They just do not need them. Yeah, but it is a bit more expensive. . . So, the product is available. We export quite a lot to Russia, Pakistan and I do not know where. Over there, they could not care less how it is produced, as far as it is cheap. We are a bit in a quandary; the farmers rather want to do it another way, but they are left with no choice.'

Cost control was realized through feeding low-quality feeds and by postponing costly improvements in suboptimal housing and climate conditions, which resulted in an increased sensitivity of animals for infectious diseases. Farmers also minimized the amount of hired labour to do the work at the farm, resulting in less attention for weak or diseased animals which increases the risk of disease transmission within the herd.

R4: 'So the economy is a difficult one. See, a farmer might choose to order cheap feed, and then we are talking about 1 or 2 euros cheaper. You can administer a lot of medicines for that money.'

R10: 'I had a pig farmer in my practice with 1000 sows, who asked me: "Give me one single reason why I should spend more money for less result. Those antibiotics of yours, they are effective! And if I have to change practices, I have to hire another worker; just costs too much money.'"

The perceived willingness of farmers to invest in vaccinations or intensive veterinary support varied. A swine veterinarian encountered objections after suggesting vaccinations as a mean to prevent infections.

R5: 'Then a farmer considers the costs and benefits. He considers whether to treat those animals with antimicrobials or to vaccinate them. That PIA-vaccine costs about 2 euros and when he treats them with antimicrobials, he only has to spend about 1 euro. If he says "I will not vaccinate, I am going to treat them with antimicrobials," well, there is nothing to stop him doing this.'

Many disease problems are believed to arise due to the 'low quality' of young animals that arrive at raising farms. Veal calves often have insufficient maternal immunity and because of their diverse origin can introduce all kinds of infections to raising farms. Broilers also often suffer from (sub)clinical infections at the time of arrival according to some respondents due to cost control measures at hatcheries. This eventually increases disease risks and antimicrobial use at the raising farm.

R2: 'When the chicks and the feed are of inferior quality, then you cannot expect chickens to arrive at the slaughterhouse without medicines.'

Farmer skills and behaviour

According to almost all respondents, high use of antimicrobials in farm animals could partly be explained by insufficient skills of farmers to detect risk factors for diseases or early signs of upcoming diseases followed by proper management adjustments. Other farmers just lack the motivation to ban antimicrobials according to some respondents. They are accustomed to raising animals with the use of antimicrobials during periods of (perceived) high disease risks and are simply reluctant to ban antimicrobials from their working routine.

Respondents made several suggestions for improving animal health. Farmers should become better educated and supervised in caretaking of animals. Two respondents suggested a licence to produce (i.e. demonstrable training or education) for farmers and their co-workers based on compulsory education and additional requirements as a prerequisite to raise and keep animals for food production. Veterinarians could potentially support farmers with insufficient management skills or motivation to improve animal health by means of more frequent veterinary supervision.

R10: *'Eh. . . motivation, that is the most important. To tackle things structurally and to look at the farm from a different perspective. But also something as talent is important; the skills to watch over animals and to implement the right actions before a problem arises. Something else for pig farming is structure. If that is not in the farmer, then it is without prospects. Or you need to direct the farmer in such a farm protocol that he can manage it. So if this farmer is guided into a 4 week system [a certain management protocol -DS], it can succeed. He should be forced to take good actions.'*

Proper Diagnosis of Animal Diseases

Proper history taking and clinical examination are fundamental to make a correct clinical diagnosis according to the respondents. When groups of sick animals are involved, other sources such as farm history of diseases, farm inspection and data inspection are major additional contributors to the diagnostic process.

Reasons (not) to use diagnostic tests

All respondents considered diagnostic tests valuable for confirmation of diagnoses and helpful in the decision whether or not and which antimicrobials should be used. Some valued diagnostic tests as an effective tool to convince farmers with objective evidence of the presence or absence

of certain infectious pathogens and the need for management adjustments.

Despite the perceived value of diagnostic tests, they were often not used. In particular, when individual diseased animals were involved, diagnostic tests were often more costly than just the empirical administration of antimicrobials. Many diagnostic tests were perceived as having results that were unavailable on a timely basis, and when faced with clinical symptoms, respondents felt an urge to treat animals immediately. During acute disease outbreaks in groups of animals, diagnostic tests were occasionally used retrospectively by respondents to adjust an already started therapy or to guide any future treatment at the same farm.

R8: *'Then you immediately start with antimicrobial group treatment. Because treating 350 piglets individually, that is not feasible at that very moment. Then you also do not await a report from the Animal Health Service [veterinary laboratory - DS] or something. Then you need to act immediately. There was mortality already. Then really something must be done, otherwise you have to drag most of them to the road [for destruction - DS].'*

When diagnostic tests did not add extra information in the opinion of the farmers, they might lose their motivation to perform often expensive diagnostic tests. In these cases, some respondents considered it difficult to convince farmers to perform diagnostic tests.

R10: *'In fact, we have too little guidance to. . . Say; if you have a problem caused by streptococci, how often will you send material for post mortem examination? So I do it regularly, but regularly. . . Once a year also is regularly but is insufficient to justify antimicrobial use.'*

DS: *'So why do you not perform diagnostic tests more often?'*

R10: *'Because, usually there is the same finding each time and then the motivation of the farmers to do this investment is lacking. "Yes, it is another streptococcus, we knew that". You really need tools and rules, with which you can say. . . You need a big stick; okay, we do it four times a year as part of our monitoring and then we can keep an eye on the sensitivity of the streptococcus.'*

In some cases, diagnostic tests were not regarded as having added value. During outbreaks of respiratory diseases in veal calves, it is likely to find multiple pathogens and it is difficult to assign the disease to only one pathogen. In some instances (e.g. *Clostridium* spp. infections), the cultured pathogenic bacteria are also found in healthy animals, so there is very limited added value of this culture result. In practice, it is then just a matter of empirical treatment – which is sometimes based on macroscopic

post-mortem examinations – and proper therapy evaluation.

Selection and Administration of Antimicrobials

Determinants for antimicrobial choice

Most respondents indicated that formularies (treatment guidelines) from the KNMvD and summaries of product characteristics are generally leading in their choice for an antimicrobial. However, based on their empirical experience and practice routines and the results of sensitivity testing, they deviated from formularies and product approvals. One respondent mentioned that for some indications, their experience had taught them that the results of an antimicrobial intervention in the field sometimes conflict with the results of sensitivity testing in the laboratory, and then, the latter was ignored. Several respondents indicated that the administration of medicines should be as convenient as possible for the farmer to increase therapy compliance. Thus, administration route and administration interval as well as withdrawal times for slaughter or milk delivery were also considered when choosing an antimicrobial.

Prophylactic use of antimicrobials

Some respondents mentioned that prophylactic (disease prevention) and metaphylactic [mass medication of groups of food animals when infectious diseases are incubating (Prescott, 2008)] antimicrobial treatments were until recently believed to be a convenient and cheap way to control infectious diseases in farm animals. Most respondents indicated that these practices had greatly been abandoned, although some prophylactic and metaphylactic antimicrobial treatments were seen as inevitable.

Several respondents mentioned that antimicrobials were still used prophylactically to prevent problems with a high probability of occurrence. They argued that if these infections were not prevented, they could cause high morbidity and mortality rates with accompanying financial losses and subsequently had to be treated with antimicrobials which were expensive, highly important for public health, or both.

R9: *'We have very bad experiences with selective dry cow therapy [restricting intramammary antimicrobial treatment only to cows demonstrable infected at drying-off, instead of blanket dry cow therapy for all animals-DS]. With current knowledge I consider it really dangerous to strictly introduce this practice. I think that we are running the risk of very serious accidents. If you get more mastitis due to this practice, then you just run into more problems, more antimicrobial use.'*

Dependency

Several respondents sometimes experienced conflicting roles. There was the pressure of working in a competitive market to deliver veterinary services to farmers. Client satisfaction was therefore important for veterinarians to remain in business. On the other hand, veterinarians felt the expectation to safeguard public health which sometimes was perceived to conflict with the interests of farmers, for example in the case of reduction of antimicrobial use. Some respondents mentioned situations in which they felt pressure from farmers or influential non-veterinary farm advisors to prescribe antimicrobials. Refusing a strong request from a farmer for antimicrobial prescription felt uncomfortable.

R7: *'Because, apart from the fact that you are convinced of something, there also still is a need to remain in business, eh. . . I mean. . . See, you may not really support some things, but you also not easily say no to a client. Because you have a certain. . . Because he assures your livelihood!'*

R6: *'And if you are going to act as a police officer, then you will lose lots of clients.'*

Most respondents had occasionally experienced feelings of frustration as they can only give recommendations to prevent diseases to farmers without enforcement of implementation. When farmers did not follow advices and veterinarians were again confronted with sick animals, they felt their professional obligation to prescribe to reduce animal suffering.

R3: *'I guess, 10–15% of the farmers are just stubborn. That really is the biggest frustration. Too often there is, unjustified I think, administration of antimicrobials to camouflage the farmer's mismanagement.'*

Many respondents, however, recognized a slow change in the attitude of farmers. Farmers that had personally been confronted with isolation measures because of a potential methicillin-resistant *Staphylococcus aureus* (MRSA) colonization at hospital submission were increasingly motivated to reduce antimicrobial use on their farm. Political and public pressure had also slowly changed the attitude of farmers. This made it increasingly easier to talk with farmers about reducing antimicrobial use.

Antimicrobial resistance

Views differed between respondents regarding the veterinary contribution to antimicrobial resistance in humans. Some were very motivated to reduce veterinary antimicrobial use for public health reasons. Others doubted a significant contribution of veterinary antimicrobial use to antimicrobial resistance in humans. They hardly ever encountered therapy failures due to resistance problems in

daily veterinary practice and considered antimicrobial resistance mainly a problem caused by inadequate prescribing practices of physicians and international traffic. Several respondents would like to see a sound scientific backing of the current Dutch policy to halve antimicrobial use in farm animals. They feared impairments of animal welfare due to non-treatment of diseased animals and were not convinced of the effectiveness of this measure in terms of reduction of antimicrobial resistance. All respondents considered it their duty as veterinarian to treat diseased animals for reasons of animal welfare and animal health, regardless of antimicrobial resistance issues.

R2: 'Those animals really can be seriously diseased. Then I also think we have to safeguard animal welfare and then I prescribe.'

Some veterinarians viewed the excellent registration of antimicrobial use in the Netherlands as the cause of the prevailing view that Dutch farm animals are amongst the highest antimicrobial consumers in Europe. They had the strong impression that veterinary antimicrobial use in surrounding countries was at least at the same level as in the Netherlands. Many respondents shared the opinion that policies regarding reduction of veterinary antimicrobial use should be equal in all European countries to prevent illegal imports of antimicrobials and to maintain a level playing field in terms of competitiveness on international markets. They doubted any effect on antimicrobial resistance if only national level measures were taken to combat antimicrobial resistance.

Practices to reduce antimicrobial use

Most respondents mentioned a high reduction in the number and extent of routine preventive antimicrobial administrations as a response to the recently introduced policy to halve veterinary antimicrobial use. Where possible, group treatments were increasingly replaced by treatment of individual animals. This approach is generally more labour-intensive and more expensive than mass medication, so it can therefore sometimes be difficult to convince farmers to waive a group treatment.

Mild clinical symptoms were increasingly treated by supportive therapies only, according to the respondents, although it very much depended on the willingness of the farmer whether antimicrobial therapy was omitted or postponed in such situations. When confronted with more severe symptoms, fear of complications after non-prescribing usually was a strong motivator to turn to antimicrobial intervention.

Veterinary pharmacy

Where antimicrobial selling in the past substantially added to the pharmacy incomes of veterinarians, all respondents

stated that pharmacy incomes from antimicrobial selling were no longer a stimulus to prescribe antimicrobials. Some respondents mentioned that pharmacy incomes from selling antimicrobials had been replaced by selling vaccines and non-steroids which they did not consider to be a threat for public health. Most respondents were reticent to increase their hourly (consultancy) tariffs for veterinary services out of concern for a negative influence on the motivation of farmers to hire them for veterinary advices. Therefore, low consultancy tariffs were regarded necessary which could only be compensated with pharmacy incomes to earn a decent income. Separating prescribing and dispensing was not expected to reduce antimicrobial prescribing in farm animals. As animals continue to contract illnesses, a need to prescribe antimicrobials would remain according to the respondents.

Discussion

This is one of the first studies to identify the underlying factors influencing prescribing behaviour of veterinarians working in farm animal practice. What becomes clear from this study is that veterinarians, like physicians, act in a playing field where many conflicting intrinsic beliefs and extrinsic influences like economic powers, client dependence and risk avoidance act as both drivers and barriers to changing their antimicrobial prescribing behaviour (Butler et al., 1998; Simpson et al., 2007). The three different levels for promotion of prudent antimicrobial use that were distracted from these results (prevention of diseases, correct diagnosis making and correct selection and administration of antimicrobials) are considered useful to structure future interventions (Aarestrup et al., 2008; Prescott, 2008; Calens et al., 2012; Pardon et al., 2012; Persoons et al., 2012).

Opinions, knowledge and skills of veterinarians

Prevention of animal diseases can largely contribute to reduction of antimicrobial use in farm animals. Several respondents mentioned that veterinarians could benefit from more practical applicable knowledge about disease control at the farm, a finding that is confirmed by a study from Gunn et al. (2008). Another finding is that there are opportunities for improvements in advisory skills of veterinarians (Jaarsma et al., 2008; Derks et al., 2012; Jansen and Lam, 2012). It might not be a matter of just acquiring more technical knowledge, but a matter of acquiring a comprehensive set of knowledge about animal management, nutrition, environment, genetics, infectious diseases, production disorders, veterinary pharmaceuticals and farm economics, supplemented with skills and attributes to put this knowledge into practice (LeBlanc et al., 2006; Mee, 2007).

All respondents felt a moral obligation towards society to reduce veterinary antimicrobial use although many questioned the veterinary contribution to antimicrobial resistance. The fact that serious resistance issues were not often encountered in daily veterinary practice might feed their belief that antimicrobial resistance is not a big and urgent issue which should be taken into account in their prescribing decisions at specific instances. Fear of major complications with deterioration of animal welfare, high mortality rates, economic consequences and client dissatisfaction after not prescribing seems to be more important for farm animal veterinarians than the more abstract risk of antimicrobial resistance. These findings are confirmed by Dean et al. (2011).

The trade-off between the direct interest of the individual sick animal or group of animals with fear of complications and its associated consequences after non-prescribing and the interests of the community in terms of the antimicrobial resistance threat for public health is also recognized in studies dealing with antimicrobial prescribing of physicians (Butler et al., 1998; Petursson, 2005; Simpson et al., 2007; Hulscher et al., 2010a,b; McNulty and Francis, 2010). Even with quite firm evidence for non-efficacy of antimicrobials in certain clinical conditions, physicians still favour the avoidance of risks and reaching client satisfaction by prescribing antimicrobials above serving public health interests by not prescribing. The evidence for non-efficacy of antimicrobials for the most treated clinical symptoms (respiratory and gastrointestinal disorders) in farm animals is limited or non-existent and is usually complicated by the fact that in a group of diseased animals, different clinical symptoms can be present which complicates the diagnostic process and thereby the rationality of waiving antimicrobial intervention.

In the view of some respondents, specific prophylactic and metaphylactic administrations of antimicrobials contribute to prudent veterinary antimicrobial use by lowering the amount of curative used antimicrobials and by protecting animal health and welfare. It is not known whether and to what extent prophylactic and metaphylactic use of antimicrobials contributes to or jeopardizes prudent veterinary antimicrobial use and animal welfare (Morley et al., 2005). However, it has been shown that even without these practices, antimicrobial reduction can be accomplished under modern circumstances without deteriorating animal health and welfare and production results (Wierup, 2000, 2001; Cromwell, 2002; Vaarst et al., 2006; Bennedsgaard et al., 2010; Anonymous, 2011; Persoons et al., 2012).

Farmers

Ultimately, farmers are the final decision makers when it comes to whether or not effective preventive measures for

infectious diseases will be implemented, whether or not diagnostic tests will be performed, and whether and which therapy will be started. They are often also responsible for the administration of antimicrobials. Not all farmers are able or willing to change practices out of risk avoidance, insufficient knowledge of the benefits or financial reasons (Gunn et al., 2008; Klerkx and Jansen, 2010). This highly influences the necessity of treating animals with antimicrobials and confronts veterinarians with a difficult dilemma for they have the professional obligation to alleviate animal suffering as well as to protect public health interests (Morley et al., 2005; Dean et al., 2011). Most respondents experienced a varying level of pressure to comply with the implicit or explicit demand of farmers and other advisors, as found in other studies (McIntosh et al., 2009; Jan et al., 2012). Losing a client might have serious financial consequences, and therefore, a stable veterinarian–farmer relationship is very valuable (Klerkx and Jansen, 2010). It is interesting to know whether farmers' expectations for prescriptions or lack of motivations for management changes are correctly or wrongly perceived by veterinarians. It is known from physicians that the perceived expectation for antimicrobial therapy does not always correspond with the actual expectation of the patient (Butler et al., 1998). In the veterinary domain, it has been found that ostensibly unwilling farmers might in reality be willing to implement management adjustments, although they should probably be approached with different arguments (Jansen et al., 2010). This might be related to insufficient knowledge transfer; farmers must be convinced of the efficacy and economic benefits of implementing preventive measures (Gunn et al., 2008). Compulsory continuing education for farmers as 'a licence to produce', as suggested by some respondents, might be considered to improve the level of knowledge of farmers on disease prevention, although other approaches like annual development of action plans in collaboration with farm veterinarians might also be an effective way to increase disease-preventing measures (Speksnijder et al., 2014). However, at the end of the day, the ultimate responsibility to produce animal-derived food with high food safety, public health and animal welfare standards and to implement specific preventive measures rests with the farmer. It is up to governments or quality systems (including continuing educational systems) to enforce compliance of farmers to these high standards when these are not met, in order to protect public health interests.

Profitable Veterinary Herd Health Advisory Services

Presumably, a large reduction of antimicrobial use can be accomplished through higher emphasis on preventive measures at farm level whereby the farm veterinarian plays an

important advising and supervising role. A huge constraint is the barrier to make this regular Veterinary Herd Health Advisory Service (VHHAS) profitable without being dependent on incomes from dispensing veterinary drugs or vaccines. A recent study indicated that 40% of the dairy farmers would reduce the time spent on VHHAS if the tariffs would increase (Derks et al., 2012). It has been shown that intensive contact between a farmer and veterinarian might increase animal health so decreasing the frequency of VHHAS might result in a deterioration of animal health (Lam et al., 2011). This obstacle should be tackled if sustainable VHHAS without additional pharmacy incomes will become the norm.

Diagnostic tests

Many respondents described diagnostic tests as expensive and time-consuming, thereby hampering their execution to refine diagnoses. In human health care, the introduction of new point-of-care testing devices has enhanced faster decision-making and prudent antimicrobial prescribing, although these tests should be used with caution for the tests that vary in their performance (Price, 2001; Cals et al., 2010). The introduction of faster diagnostic tests could in some situations be beneficial in veterinarians' decision-making, although when groups of animals are concerned, multiple pathogens are often simultaneously involved which might complicate the use of rapid point-of-care testing.

Global concern

The livestock sector in the Netherlands is representative of large-scale livestock production systems that exist in many industrialized countries and which are highly internationally oriented. In most of these systems, farmers as well as private veterinarians work in a very competitive environment. International collaboration is needed to effectively reduce the development of antimicrobial resistance and to remain a fair and level playing field in terms of competitiveness on international markets and to prevent illegal imports of antimicrobials (Speksnijder et al., 2014). Although specific contexts may differ, we think that many of the determinants that influence antimicrobial prescribing behaviour of farm animal veterinarians in the Netherlands do also apply to veterinarians working in comparable livestock systems worldwide. This is supported by the scarce literature dealing with prescribing determinants of farm animal veterinarians (McIntosh et al., 2009; Jan et al., 2012).

Implications

To increase veterinarians' and farmers' confidence in achieving a sustainable reduction in antimicrobial use in

farm animals, they should be provided with evidence-based, feasible approaches and tools to help achieving this change (McNulty and Francis, 2010). Clear evidence could be presented dealing with the consequences of veterinary overuse of antimicrobials and the need to reduce veterinary antimicrobial use. Existing knowledge about best practices to reduce antimicrobial use without compromising animal health and production results should be further disseminated amongst veterinarians and farmers to convince them of the feasibility of production with less use of antimicrobials. As veterinarians are seen as highly influential referents regarding biosecurity issues, there might be a huge role for veterinarians in motivating and advising farmers to implement preventive control measures (Ellis-Iversen et al., 2010). Improved advisory skills of veterinarians might well further substantiate the effect of VHHAS. Veterinarians should also learn to deal with sometimes contrasting opinions of other farm advisors, and ways should be found to harmonize the advice of different consultants to improve farmers' compliance (Lam et al., 2011).

Additional policy instruments might be needed for a better compliance to veterinary advice to control animal diseases (Morley et al., 2005; Klerkx and Jansen, 2010). Disease-specific guidelines that also include recommendations for performing specific diagnostic tests and preventive measures to prevent diseases might be beneficial in substantiating veterinary advice to farmers, although some farmers might not voluntarily comply and should ultimately probably be enforced by independent parties (Aarestrup et al., 2008; Prescott, 2008).

Limitations of the Study

As this study is qualitative in origin, it is not possible to rank the found prescription determinants in importance nor can these results be generalized over the whole veterinary profession (Pope et al., 2000). For this goal, a questionnaire for dissemination in a larger group will be developed based on the results of this qualitative exploration.

The public currently holds a negative attitude towards extensive antimicrobial use in farm animals (Derks et al., 2012; Dijkma, 2014). Interviewed veterinarians might be aware of this negative image and could have tended to give socially desirable answers. However, the fact that the interviewer is a peer of the respondents probably has reduced the hierarchy between informants and researcher (Chew-Graham et al., 2002; Coar and Sim, 2006; DiCicco-Bloom and Crabtree, 2006). Respondents were very frank in describing their daily practices, leading to the impression that the participating veterinarians really expressed their true feelings and behaviour (McNair et al., 2008).

The number of respondents (eleven) is relatively low. The estimated population of private farm animal veterinarians in the Netherlands is around 1100. However, saturation of data was reached and the performance of additional interviews was not expected to provide additional information for the purpose of revealing possible prescribing determinants for farm animal veterinarians. Relatively small sample sizes can be sufficient to understand common perceptions and experiences amongst a group of relatively homogeneous respondents (Guest et al., 2006; Onwuegbuzie and Leech, 2007).

Conclusions

This study indicates that antimicrobial prescribing by veterinarians is influenced by a very complex set of internal attitudes and beliefs and external, often conflicting, interests. To reduce the overall use and misuse of antimicrobials in farm animals, three different challenges can be distinguished: (i) the successful and consistent implementation of preventive measures at farm level, (ii) the reduction in thresholds for the use of diagnostics and (iii) the prudent and accurate administration of antimicrobial treatments. All kinds of identified stakeholders have responsibilities at these challenges and have to change behaviours. International collaboration in reducing antimicrobial use is needed to maintain international competitiveness of national livestock sectors and to remain support of all stakeholders. Single, simple solutions are unlikely to alter antimicrobial prescribing of veterinarians. A comprehensive set of multiple interventions addressing different aspects of prescribing behaviour, together with flanking policy measures to enforce compliance of all the stakeholders, is needed.

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Disclaimer

JAW is a member of the expert panel of the Netherlands Veterinary Medicine Authority (SDa). The opinions expressed in this manuscript is his personal opinion and not of the SDa.

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Appendix1: Interview guide

Veterinarian

Role of veterinarian

- How do you perceive your role as a veterinarian on a farm?
- Which steps do you take when you are being confronted with (a) sick animal(s)?
 - Way of approaching the problem
 - How the diagnose is made
 - Choice of therapy

Prescribing

- How do you define 'prudent antimicrobial use'?
- How do you perceive your own prescribing behavior?
 - Antimicrobial resistance and reduction of antimicrobial use
 - How do you consider antimicrobial resistance?
 - Current policies to reduce antimicrobial use?
 - Influence on daily work?
 - Barriers and opportunities for reducing antimicrobial use in farm animals?
 - Role of veterinarians in reducing antimicrobial uses in farm animals?
 - What about your own knowledge and skills to reduce antimicrobial use?

Farmers and non-veterinary advisors

Relationship between veterinarian and farmer

- Expectations of farmers towards you as a veterinarian?
- Role of farmers and non-veterinary advisors in the choice for antimicrobial therapy?
 - Pressure on you in your considerations to start a certain therapy?
 - How do you deal with pressure to prescribe?
 - Tools or skills to deal with pressure?

Antimicrobial use on a farm

- Important factors on a livestock farm that determine the scale of antimicrobial use?
 - How can these factors be influenced?
- Motives of farmers (not) to apply antimicrobials on their animals?
 - Actors or factors influencing these motives?
 - Role of veterinarians in influencing these motives?
- Role of prophylactic and metaphylactic antimicrobial use on an average farm?

Organization of the livestock sector and animal health care

Influence of the organization of the livestock sector on animal diseases and antimicrobial use

- Influence of the current organization of the livestock sector on the scale of animal diseases?
 - Influence on antimicrobial use in the livestock sector you are working in?
 - Value of initiatives taken by the livestock sector to reduce antimicrobial use?
 - Suggestions for improvements?

Organization of animal health care

- Coordination between colleagues in your practice in terms of therapy choices, treatment protocols etc.?
- Role of diagnostic tests in reduction of antimicrobial use?
 - Which potential role in future? What is needed for that?
- Current veterinary infrastructure in the Netherlands?
 - Which improvements might be possible?
- Role of formularies, guidelines etc. in healthcare for livestock?
 - Which requirements to be effective?

Cultural and Socio-economical context

Public and political aspects

- Current public and political debate about antimicrobial use in livestock?
- Role of veterinarians in public health?
 - Which obstacles experienced?
- Role of government in the current issue of antimicrobial use in livestock?
- What should the position of veterinarians in the livestock sector and his/her public tasks be (in terms of public health and animal welfare issues)?
 - How can this position be strengthened?

Economic considerations of veterinarian and farmer

- Role of veterinary pharmacy for income of veterinarians?
- Financial considerations of farmer in using antimicrobials?