ACVIM Consensus Statement

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Consensus Statements of the American College of Veterinary Internal Medicine (ACVIM) provide veterinarians with guidelines regarding the pathophysiology, diagnosis, or treatment of animal diseases. The foundation of the Consensus Statement is evidence-based medicine, but if such evidence is conflicting or lacking, the panel provides interpretive recommendations on the basis of their collective expertise. The Consensus Statement is intended to be a guide for veterinarians, but it is not a statement of standard of care or a substitute for clinical judgment. Topics of statements and panel members to draft the statements are selected by the Board of Regents with input from the general membership. A draft prepared and input from Diplomates is solicited at the Forum and via the ACVIM Web site and incorporated in a final version. This Consensus Statement was approved by the Board of Regents of the ACVIM before publication.

Antimicrobial Drug Use in Veterinary Medicine

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Recognizing the importance of antimicrobial resistance and the need for veterinarians to aid in efforts for maintaining the usefulness of antimicrobial drugs in animals and humans, the Board of Regents of the American College of Veterinary Internal Medicine charged a special committee with responsibility for drafting this position statement regarding antimicrobial drug use in veterinary medicine. The Committee believes that veterinarians are obligated to balance the well-being of animals under their care with the protection of other animals and public health. Therefore, if an animal's medical condition can be reasonably expected to improve as a result of treatment with antimicrobial drugs, and the animal is under a veterinarian's care with an appropriate veterinarian-client-patient relationship, veterinarians have an obligation to offer antimicrobial treatment as a therapeutic option. Veterinarians also have an obligation to actively promote disease prevention efforts, to treat as conservatively as possible, and to explain the potential consequences associated with antimicrobial treatment to animal owners and managers, including the possibility of promoting selection of resistant bacteria. However, the consequences of losing usefulness of an antimicrobial drug that is used as a last resort in humans or animals with resistant bacterial infections might be unacceptable from a public or population health perspective. Veterinarians could therefore face the difficult choice of treating animals with a drug that is less likely to be successful, possibly resulting in prolonged or exacerbated morbidity, to protect the good of society. The Committee recommends that voluntary actions be taken by the veterinary profession to promote conservative use of antimicrobial drugs to minimize the potential adverse effects on animal or human health. The veterinary profession must work to educate all veterinarians about issues related to conservative antimicrobial drug use and antimicrobial resistance so that each individual is better able to balance ethical obligations regarding the perceived benefit to their patients versus the perceived risk to public health. Specific means by which the veterinary profession can promote stewardship of this valuable resource are presented and discussed in this document.

Key words: Antibacterial; Antibiotic; Prudent use; Resistance.

Antimicrobial drugs are used in animals, humans, and plants to treat and prevent bacterial infections and to improve production efficiency in food-producing animals. These drugs are among the most important tools available to modern medicine. Few developments have had as dramatic an effect on human and veterinary medicine during the previous century as the development of antimicrobial drugs and their use for prevention and treatment of bacterial diseases. However, soon after antimicrobial drugs became readily available for use in human and veterinary medicine, it was recognized that decreased bacterial susceptibility could adversely affect clinical outcome. It is now widely recognized that susceptibility to these drugs is not universal among all bacterial species, nor is it equal between different strains of the same bacterial species. Resistance mechanisms can either be intrinsic or acquired through a variety of genetic means. Variability in susceptibility to different antimicrobial drugs has become a major factor affecting the successful treatment of bacterial diseases. It is also commonly but incorrectly assumed that only the target bacteria are being exposed to antimicrobial drugs when the host is treated. Most if not all commensal and transient microbial flora are exposed to varying amounts of antimicrobial drug during treatment. Although resistance in these so-called bystander bacteria might not be of consequence in one host species, these organisms can cause disease in other hosts,

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and all resistant bacteria could serve as reservoirs of resistance genes.

The extent to which antimicrobial resistance is affecting the health of humans and animals is not known. There are concerns that emerging resistance among bacteria, if left unchecked, could escalate to the point at which efficacy of many of the most important drugs will no longer be predictable and some bacterial infections could once again become untreatable. Although substantial debate surrounds this issue, research is needed to further document the risks to humans and animals posed by antimicrobial resistance because scientifically sound information is largely unavailable.[1–3] However, there is increasing global pressure to develop strategies to protect the effectiveness of existing and new antimicrobials by reducing selection pressure driving emerging resistance in bacteria. Not only is there substantial pressure to do something, there is emphasis from many sectors to do it immediately, which has the unfortunate consequence of causing authorities to sometimes act in the absence of definitive scientific data.

The World Health Organization (WHO), the US Centers for Disease Control and Prevention (CDC), the US Food and Drug Administration (FDA), the US Department of Agriculture (USDA) and many other agencies involved in promotion and regulation of health activities around the world are vigorously engaged in developing programs intended to monitor the emergence of antimicrobial resistance and to decrease use of antimicrobial drugs. Use of antimicrobial drugs in human medicine is thought to be responsible for a large part, if not the majority, of the resistance problems observed today,[1,4] but a considerable portion, if not the majority, of scrutiny has focused on antimicrobial use in animals. This is because of the potential for and perceived importance of zoonotic transmission of pathogenic and nonpathogenic bacteria to humans through direct contact with animals, indirectly through contact with animals' environments or through the food chain.

Veterinarians in the United States and many other countries are responsible for overseeing the use of most antimicrobial drugs in animals for therapeutic or disease prevention. Veterinarians should therefore critically evaluate current antimicrobial use to identify ways to modify use without adversely affecting the health and well-being of animals or humans. The American College of Veterinary Internal Medicine (ACVIM) recognizes the importance of this issue and the need for veterinarians to contribute to efforts intended to maintain the usefulness of antimicrobial drugs in animals and humans and specifically to monitor and help assure that the use of antimicrobial drugs in veterinary medicine has a minimal negative effect on human health. As such, the ACVIM Board of Regents approved convening a special committee and charged it with responsibility for drafting this position statement regarding antimicrobial drug use in veterinary medicine. Experts with diverse backgrounds related to this issue were identified to assist with this effort. Members of the Committee included ACVIM Diplomates and other veterinarians clinically experienced in working with small animals, equine, and food animal patients, in addition to specialists experienced in food animal production. The group also included microbiologists, pharmacologists, epidemiologists, and infectious disease specialists with considerable research experience related to the action of antimicrobial drugs; their use in treatment of animals; and the ecology, surveillance, and epidemiology of antimicrobial resistance. These professionals work in private veterinary practice, academia, and the federal government and are members and officers in more than 20 professional organizations related to veterinary medicine and animal health (see Appendix). Through extensive discussions, this Committee prepared a draft of this document that was presented at the 2003 ACVIM Forum and posted for comment on a Web site. Comments were considered, and a final draft was sent for review and approval to the ACVIM Board of Regents before publication.

Several veterinary organizations have previously published and endorsed documents regarding principles of judicious antimicrobial drug use in veterinary medicine.[5] The Committee's intent in drafting this statement was not to emulate or replace these previous efforts. Rather, the goal of this Committee was to expand upon previous efforts by providing more in-depth discussion of issues faced by veterinarians when attempting to apply guidelines for judicious use in everyday practice situations. Although all of the actions recommended in this document relate to antimicrobial use by individual practicing veterinarians, their scope could involve remedies on a larger scale, such as by the ACVIM, the veterinary profession, the US government, or other regulatory bodies.

This statement will specifically address antimicrobial drug use for treatment and prevention of disease in animals, and recommendations in this document are not intended to be extrapolated to other uses. The use of antimicrobial drugs for enhancement of production efficiency is not addressed. The ACVIM acknowledges that antimicrobial resistance is a complex issue with ramifications extending beyond the scope of this paper.

Background

Antibiotics are compounds produced by living organisms that impede the growth of other organisms. Antimicrobial drugs include antibiotics as well as synthetic and semisynthetic compounds that have the same effects. Antimicrobial drugs have a variety of actions to affect bacterial survival and growth, including inhibition of cell wall synthesis (penicillins and cephalosporins), inhibition of protein synthesis (tetracyclines, macrolides, phenicols, aminoglycosides), and inhibition of DNA function (sulfonamides and fluoroquinolones). Antimicrobial drugs can be classified as having bactericidal or bacteriostatic action. Bactericidal antimicrobial drugs have minimum inhibitory concentrations (MICs) and minimum bactericidal concentrations (MBCs) that are only a few dilutions apart when evaluated in the laboratory. Bacteriostatic antimicrobial drugs inhibit or arrest growth without actually killing the bacteria and generally require a greater increase in concentration to inhibit visible growth in culture (MIC).

The primary goal of antimicrobial drug use for treatment and prevention of bacterial infections should be to control bacterial growth to enable host responses to contain or eliminate bacteria responsible for disease. Although antimicrobial drugs can help the host contain and eliminate infections, these drugs should not be considered solely responsible for eliminating infections in the host because both innate and developed immune responses are critical in this process. Nor should antimicrobial drugs be applied for disease prevention with the mindset that they are the sole or most important means of preventing disease caused by bacterial agents. For example, preventing or minimizing exposure to infectious agents are far more effective means of preventing infectious diseases, and optimizing immune status can minimize the effect of infections without use of antimicrobial drugs.

Mechanisms for Resistance to Antimicrobial Compounds

Bacteria can be resistant to the action of antimicrobial drugs because of the inherent structure or physiology of the bacteria (constitutive resistance), or they can develop mechanisms to circumvent action of the drugs through genetic mutation or through acquisition of genetic elements (acquired resistance).

It is important to note that contact with antimicrobial drugs is not believed to cause bacteria to actively mutate or develop new types of resistance. Genetic mutation is a normal process that occurs during bacterial replication and occurs spontaneously in DNA replication at a rate of 1 mutation per million bases per cell division.[6] Because of the large number of bacteria produced during replication and the short generation interval, mutation is a common event. Although most mutations are likely detrimental to the organism, by random chance, a mutation can develop that provides selective advantage to bacteria exposed to antimicrobial drugs, which therefore favors survival of strains less susceptible to the antimicrobial drug.

Some examples of mechanisms for intrinsic or constitutive resistance include a lack of cellular mechanisms required for antimicrobial action (ie, penicillin resistance because of a lack of correct binding proteins), growth rates too slow for effective action (beta-lactam antimicrobials), and resistance in anaerobic bacteria to aminoglycosides from a lack of oxygen-dependent uptake of the antimicrobial into the bacterial cell. Several mechanisms are also associated with acquired antimicrobial resistance. These include drug inactivation, drug modification, production of competitive metabolites, target mutation, target substitution, target modification, decreased cell wall permeability to drugs, active efflux of drugs, and failure to metabolize a drug to its active form. Some antimicrobial drugs such as tetracyclines and macrolides are associated with multiple mechanisms of resistance that confounds development of effective means to overcome this resistance. Continued exposure of bacterial populations to antimicrobial drugs or other factors affecting survival (such as disinfectants, metals, pH, and presence of specific nutrients) after the bacteria acquire genetic material conferring resistance to antimicrobial drugs can provide a selection pressure resulting in an increase in prevalence of resistance among populations of those bacteria.

Transmission of Genetic Elements

Bacteria can acquire genes conferring resistance by a variety of mechanisms, including acquisition of extrachromosomal plasmids that replicate apart from the chromosomal DNA. Plasmids can contain smaller mobile genetic elements called transposons that have the ability to move from the plasmid to chromosome and vice versa. Transposons can also be introduced into bacterial cells by bacteriophages that act as a transport vectors, by uptake of naked DNA, or by transfer from other plasmids. Recently, smaller elements within transposons called integrons have also been described. These can insert within the transposon and facilitate the further acquisition of multiple resistance genes. Plasmids can be lost when selective antimicrobial pressure is no longer present, and resistance harbored on a plasmid is typically lost when the plasmid is lost from the cell. Some scientists have suggested that once resistance genes are inserted into the chromosomal DNA, resistance is rarely if ever lost from bacteria that compete successfully in an ecosystem. However, this theory has not been examined extensively, and there are notable exceptions such as with *Salmonella* Typhimurium DT104. If genetic determinants of resistance are retained even in the absence of antimicrobial drug exposure, this would highlight the importance of preventing development of antimicrobial resistance and would have important implications on policies regarding restrictions on antimicrobial drug use.

Resistance genes are believed to transfer most commonly among bacteria of the same species. However, evidence is increasing that genetic elements can transfer among bacteria of different species, or even from different genera. Because of this ability for genetic elements to transfer among bacteria and for bacteria to be exchanged between animals of the same or different species, it is theoretically possible for resistance to emerge in bacterial populations in animals that have never been exposed to antimicrobial drugs. Recent research findings characterizing the function of integrons and transposons indicate that resistance might also be propagated for other reasons. Genetic determinants for resistance to more than 1 antimicrobial can be linked together. When bacteria are resistant to more than 1 antimicrobial, regardless of whether genetic elements are constitutively linked, exposure of these resistant bacteria to 1 antimicrobial will inadvertently promote persistence of resistance to the other antimicrobials, even if they have different mechanisms of action.

After bacteria acquire genetic material conferring resistance, continued exposure of bacterial populations to antimicrobial drugs provides the selection pressure that might allow the resistant population to increase in prevalence and subsequently become the dominant clone in the population. Whether resistance will persist at a high prevalence in bacterial populations after removal of antimicrobial pressure depends on the characteristics of competing flora in the ecosystem, the stability of the genetic determinants in the resistant organisms, and the fitness of the resistant organisms. Mutation or genetic transfer can, in addition to conferring mechanisms for antimicrobial resistance, bring about changes that might adversely affect the survival of progeny bacteria, especially when the selection pressure associated with antimicrobial exposure is removed. However, if there are no adverse consequences of maintaining resistance genes, it is wrong to assume that antimicrobial resistance will decline after withdrawal of antimicrobial pressure.

Origins of Antimicrobial Resistance

It is not possible to pinpoint how or when resistance to antimicrobial agents 1st developed, but we can make some reasonable deductions about why bacteria develop resistance. Because the single driving goal of bacterial populations appears to be survival and propagation, resistance mechanisms are most likely inherent in the molecular architecture of the cells. Although some might argue that all resistance is at some level acquired, the acquisition of resistance genes requires that insertion occur either in the chromosome or plasmid, and a logical conclusion is that these insertion sites have been programmed, or evolved, over time to accommodate molecular additions. Resistance to antimicrobial agents was 1st recognized by scientists soon after penicillin was widely used in World War II. Resistance has subsequently been recognized after introduction of each new antimicrobial drug, prompting the continued need for development of new types of antimicrobial drugs. However, since the early 1990s, a crisis has loomed in that few new antimicrobial drugs have been developed for human use, and pharmaceutical companies have ceased or dramatically reduced efforts to develop new antimicrobials. At the same time, new mechanisms that bacteria use to acquire resistance have been identified. The combined effect has been a decreased ability to effectively treat some bacterial diseases, an outcome that was considered unthinkable just a few decades ago. Treatment failure associated with antimicrobial resistance has probably been most commonly seen in human rather than in animal patients.

Transmission of Resistant Bacteria

There are other causes of evolving resistance in animal populations related to interactions at other levels of the ecosystem. These include movement of carrier animals between herds (regionally, nationally, or even internationally), managing animals in ways that increase the likelihood of transmission, exposure through feed and water, exposure through the environment (eg, contaminated soils and facilities), transmission through direct or indirect contact with infected humans, and transmission and movement through vectors and vehicles such as wildlife, insects, and birds. Studies addressing the effect of vectors and management on movement of bacteria have been described.[1] For example, animal feces in holding ponds or used as fertilizer for crops can be a potential source for bacterial contamination of soil, water, and crops, and these sources have in turn been implicated as potential sources for human exposure to resistant bacteria. However, animals are not the sole source of this type of environmental contamination because human waste (treated and untreated) is often distributed in the environment in a similar manner. It is important to remember that bacteria are ubiquitous in our ecosystems, and it is difficult if not impossible to point at 1 potential source (eg, food animals) as the sole or primary source of resistant bacteria of public health or veterinary significance.

Consequences of Antimicrobial Resistance

Objective, systematic risk analysis has been endorsed by authorities throughout the world as the most reasonable basis for evaluating and weighing risks, benefits, and consequences to society for various issues, as well as to promote better policy development and regulatory decision making by basing them on science.[7] Optimally, the risk analysis process should include a quantitative consequence assessment that attempts to determine the magnitude of consequences associated with the adverse outcome, such as antimicrobial resistance that affects human or animal health. The basic measure used in this quantification of risk is derived by multiplying the magnitude of the adverse consequence by the probability that the adverse event will occur. If the magnitude of the consequences is very large, from a societal perspective, the risk to the population will be great even if the probability of that event is moderate or low. In other words, if the consequences of the adverse event are disastrous, corrective or mitigative action could be warranted even if the likelihood of occurrence is small. This is the rationale that many agencies use when applying the so-called ‘‘precautionary principle,’’ a position of extreme risk aversion, when making policy decisions related to antimicrobial resistance and other public health concerns.

The exact probability that antimicrobial drug use in animals adversely affects the health of humans is unknown, but the potential selective effects of antimicrobial drugs cannot be denied and is most likely not zero. Regardless, if resistance to important antimicrobial drugs became common it would truly be devastating for the well-being of animals and humans. Widespread antimicrobial resistance in important pathogens would result in increased morbidity and mortality among infected individuals and increased costs for treating infections. In addition to the associated suffering related to these infections, a cascade of other adverse consequences would follow. The detrimental effect on production costs would affect the livelihood of producers, consumers would be affected by the availability and cost of animal products, and there would be potential for international trade implications. Even if resistance were only common among bacteria in animals, the potential for transmission to humans could stimulate regulatory action intended to restrict the use of certain antimicrobial drugs and reduce exposure of humans to resistant bacteria.

Ideally, quantitative risk assessment allows for objective comparison of hazards and benefits to allow logical and reasonable decision making. However, the answers obtained from the risk assessment process are only as valid as the assumptions used for the models. Currently, the gaps in data related to antimicrobial drug use and antimicrobial resistance are a major issue affecting wider acceptance of risk analysis models. In the absence of data, it seems prudent that all health professionals, including veterinarians, should actively promote reasonable efforts intended to maintain the efficacy of these drugs. There are undoubtedly antimicrobial use practices that have greater potential for promoting development of resistance, just as there are undoubtedly use practices that have lesser effects. Although caution is warranted in the absence of data, information obtained from objective, scientifically valid studies should be allowed to trump the precautionary principle when it is appropriate.

Basic Questions for the Veterinary Profession

In reviewing issues related to antimicrobial drug use in animals, the Committee identified a single overarching question that needed to be addressed to determine which comments or actions were most relevant to the charge: *Is antimicrobial drug use causing resistance to develop?* If there is no evidence to support concerns expressed by various parties, then this would seem to be more of a public relations issue than a scientific or medical problem. This general question is best addressed by breaking the issue into 3 more basic questions.

1. Is Decreased Susceptibility to Antimicrobial Drugs More Common Today than It Was in the Past? The general belief by many scientists, physicians, and veterinarians is that resistance is more commonly observed in bacterial populations today than it was in the past.[8–11] However, interest in antimicrobial resistance has fluctuated over time. Susceptibility was closely monitored when antimicrobial drugs were 1st introduced, and resistance was observed to develop shortly after introductions, particularly among the penicillins, streptomycin, and tetracyclines. Interestingly, there seems to have been no foresight among the medical or veterinary communities to establish long-range surveillance systems, and reports on resistance have been limited to anecdotal observations and sporadic studies. As additional drugs were introduced, antimicrobial susceptibility testing methods were refined, but monitoring and surveillance remained sporadic at best. Interest in the issue of resistance has increased as resistant strains of bacteria have emerged. Therefore, making appropriate comparisons of historical data is difficult. It is somewhat difficult to determine whether apparent increases in resistance resulted from increased use of antimicrobials or whether this is a biased perception created by use of more sensitive bacterial recovery methods or increased investigation of interesting bacterial strains that have developed specific resistant patterns (eg, *Salmonella* Typhimurium DT104 and *Salmonella* Newport).

Nonetheless, if antimicrobial susceptibility patterns of isolates obtained 30 or more years ago are compared with susceptibility profiles of isolates obtained recently, there are good examples where resistance appears to be most common to the older drugs such as tetracyclines, streptomycin, penicillins, and sulfonamides.[8–10,12–15] Resistance appears to be less prevalent, but emerging at varying rates, among the newer cephalosporins, quinolones, and macrolides.[16–19] However, it is critical to note that there are drug-bacteria interaction factors that must be considered. Although resistance among some genera of bacteria to some drugs is prevalent, the prevalence of resistance is not uniform across all types of drugs, all drugs in a specific class, or among bacterial species. Therefore, care should be taken to avoid overinterpreting results, and it is critical to consider epidemiologic differences when analyzing these data. Still, when comparable banks of bacteria isolated over time are evaluated by the same methods, generally, resistance has been found to be more common in recent times among *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Enteroccocus* spp., *Escherichia coli*, or *Salmonella* collected from human patients or isolated from animals. At the same time, it is not clear that antimicrobial susceptibility has changed meaningfully over time among other important bacteria such as *Mannheimia haemolytica*, *Streptococcus zooepidemicus*, or *Bordetella bronchiseptica*. Unfortunately there are insufficient data to make objective assessments regarding many and possibly most important bacteria in other specific host species (eg, *Klebsiella, Pseudomonas, Enterococcus* spp.).

2. Is There Evidence That Previous and Current Antimicrobial Use Practices Have Helped to Select for Increased Prevalence of Resistance in Bacterial Populations? In theory, any use of antimicrobial drugs results in the development of resistant populations of bacteria. A bigger question is whether these resistant populations survive and persist. Antimicrobial use applies a selection pressure to exposed bacterial populations favoring resistant strains, and continued exposure theoretically allows resistant bacteria to become more prevalent. In vitro studies conducted under very specific conditions support this theory of selection and persistence. However, in vitro studies are not available regarding every bacterial species of interest in combination with every drug that is commonly used in veterinary medicine, and in vivo studies evaluating these effects in most drug-bacteria combinations are largely unavailable. Furthermore, most investigations have largely ignored the nontarget species, which are unavoidably exposed whenever the host is treated. Although this general association is consistent with the proposed theory that exposure is associated with increased prevalence of resistance in bacterial populations, in vitro studies cannot mimic all of the ecologic factors present in natural settings and therefore cannot be used to fully predict how actual use practices will affect the prevalence of resistance among bacteria of interest. Probably a great deal of variability exists among current antimicrobial use practices with regard to their likelihood to promote antimicrobial resistance, but much more research is needed to characterize the risks associated with specific use practices. Although specific information is lacking for most bacteria-drug-host combinations, it does not negate the general impression that the longer an antimicrobial drug is used, the more common resistance becomes in bacteria.

3. Are There Actions That Can Slow or Reverse an Apparent Increase in the Prevalence of Resistance? Unfortunately, no actions have been proven to completely reverse the emergence of resistance once it becomes common in a bacterial population. However, in theory, removing exposure of bacterial populations to antimicrobial drugs might eliminate the survival advantage for bacteria that is provided by resistance mechanisms. Prevalence of resistance might then remain static or even decrease in response to this action as other advantageous traits dilute out resistance traits (that would no longer provide a survival advantage). Restrictions on antimicrobial drug use in specific institutions or premises have been correlated with subsequent decreasing prevalence of resistance in bacterial pathogens,[20–22] but there are also examples in which the prevalence has not changed after limiting the use of antimicrobial drugs.[23,24]

However, the potential or theoretical benefits of curtailing antimicrobial drug use with the goal of reducing antimicrobial resistance, or even reducing the rate of increasing resistance prevalence, rely critically on infection control. Dissemination of resistant clones is central to the increase in prevalence of antimicrobial resistance in nearly every major bacterial group in which resistance is a problem, and failure to control dissemination renders ''rational use'' guidelines essentially ineffective.

The Committee believes that there is reason for the veterinary profession to be concerned about its role in the promotion of antimicrobial resistance and justification for development of a reasonable action plan in response to this problem. The consequences of losing antimicrobial drugs as tools for combating bacterial diseases are grave. Just as is true for identifying ''proof'' of any scientific concept, for some, there probably never will be enough evidence to show that the use of antimicrobial drugs is associated with increased prevalence of resistance. However, given the serious nature of possible consequences, it is unwise to deny the selective effects of antimicrobial drugs, and it is only prudent to carefully consider and possibly minimize use of these drugs where possible. It is logical that these efforts should 1st be concentrated on those drugs that are considered treatments of last resort for pathogens that are resistant to other antimicrobial drugs.

Ethical Questions for Veterinarians Regarding Antimicrobial Drug Use and Antimicrobial Resistance

What are the Ethical Obligations to Our Patients, Our Clients, and the Public Regarding Antimicrobial Drug Use in Animals? The American Veterinary Medical Association's Veterinarian's Oath[25] places equal emphasis on professional obligations for protecting animal health, relief of animal suffering, conservation of animal resources, and promoting public health, as do similar oaths from other countries. Conceptually, it might seem possible to achieve this balance in our daily activities. However, when faced with the practical realities of antimicrobial drug use in daily practice activities, it is likely that veterinarians will be forced to prioritize among these obligations even though they have no desire to act in a manner that is harmful to the public, their patients, or their clients. If any antimicrobial drug use has the potential to promote antimicrobial resistance, then these drugs cannot be used in animal or human patients without potentially posing some risk to human and animal health. However, the Committee strongly believes that veterinarians are ethically obligated to use antimicrobial drugs, when indicated, to aid in the promotion of the health and well-being of animals. Veterinarians are also obligated, to the best of their ability, to balance the well-being of animals under their care with the protection of other animals and public health. Therefore, if an animal with a medical condition can be reasonably expected to improve as a result of treatment with antimicrobial drugs, and the animal is under a veterinarian's care with a veterinarian-client-patient relationship, then the veterinarian has an obligation to offer antimicrobial treatment to the owner or manager as a therapeutic option for their animal. However, to protect public health, the veterinarian also has an obligation to actively promote disease prevention efforts, treat as conservatively as possible, and explain the potential consequences associated with antimicrobial treatment to animal owners and managers, including the possibility of promoting selection of resistant bacteria. The consequences of losing beneficial effects of a particular antimicrobial drug, such as one that is used as a last resort in human and animal patients with multiply resistant bacterial infections, could be unacceptable from a public or population health perspective. In these situations, veterinarians might face the difficult choice of treating animals with a drug that is less likely to be successful, possibly resulting in prolonged or exacerbated morbidity, to protect the good of society. It is not possible to dictate actions for these circumstances or expect regulations to fit all situations in which this might be encountered. Rather, the veterinary profession must educate all veterinarians about issues related to antimicrobial drug use and antimicrobial resistance so that they are better able to balance ethical obligations regarding the benefit to their patients versus the risk to public health. The veterinary profession lacks reliable scientific data about which use practices are most risky and which are less likely to promote resistance. The profession also lacks information about the efficacy of actions for reducing the prevalence of resistance in bacterial populations. Although the severity of the consequences suggests that the veterinary profession should act conservatively in the use of antimicrobial drugs, the ACVIM, other veterinary organizations, and regulatory agencies should vigorously promote research activity that will provide information and tools to practicing veterinarians about these issues.

If Disease Prevention Methods Are Available to Significantly Reduce the Effect of an Infectious Disease in Animals Without the Use of Antimicrobial Drugs, but an Animal Owner or Manager Chooses Not to Adopt This Approach, Can a Veterinarian Ethically Support Therapeutic or Prophylactic Use of Antimicrobial Drugs? This is a difficult question that again is not aided by equal weighting of obligations to patients and to public welfare. Given the potentially serious consequences of antimicrobial resistance, veterinarians should use antimicrobial drugs conservatively whenever possible to minimize the adverse effect on animal or human health. However, when asked to treat ill animals by a client who has ignored veterinary recommendations that might have prevented the illness, it is difficult to say that a higher moral imperative would be fulfilled by declining to provide services to the client by refusing to treat the animals. This obviously puts veterinarians in conflict with professional obligations to alleviate suffering and promote animal well-being. On the other hand, a management system that results in continued problems with infectious diseases also conflicts with the same obligation to alleviate suffering and to promote animal well-being. Furthermore, it is difficult to say that our obligations regarding the well-being of clients or their animals are completely outweighed by conflicting considerations for the general public welfare. Last, situations might exist in which clients are essentially required to use management practices that result in adverse animal health consequences (including drug use practices that could encourage resistance development) to successfully compete economically. These situations beg for an appropriate industry compliance policy or, failing that, a regulatory approach that is supported and encouraged, if not led, by the veterinary profession. The veterinary profession is concerned about public health and animal welfare because of antimicrobial resistance. Achieving appropriate balance for all of these concerns is the essence of the dilemma. The Committee believes that the best outcome for all involved in these decisions is for the veterinary profession to make a long-term commitment to aggressively promote disease prevention whenever possible, to promote conservative use of antimicrobial drugs whenever they are needed and to draw animal industry and public attention to situations in which economic pressures encourage less conservative antimicrobial drug use so that they can help provide solutions for these issues. This balance cannot be achieved through regulation alone and will be best achieved by training veterinarians that are well grounded in their understanding of these issues and are sophisticated in their ability to provide effective disease prevention protocols combined with conservative antimicrobial drug treatment.

What Are the Ethical Obligations When a Veterinarian or a Diagnostician Becomes Aware of Illegal Antimicrobial Use Practices by an Animal Owner or a Veterinarian? It is clearly unethical for veterinarians to use antimicrobial drugs illegally, just as it is unethical to promote illegal use by others. Ignoring illegal use could be viewed as supplying tacit approval and therefore promotes this activity, even if this is not the intent of inaction. Identifying and acting in these situations, although ethically necessary, should be viewed as a failure of the profession to adequately educate veterinarians and the public about the importance of these issues. The Committee believes that the veterinary profession can voluntarily regulate use of antimicrobial drugs to balance the benefit of our animal patients and the public well-being.

Should Veterinarians Profit from the Sale of Antimicrobial Drugs? The issue underlying this question is whether profit or other incentives provide motivation for unethical overprescription of antimicrobial drugs, as has been implied by the World Health Organization.[26–28] Without question, veterinarians should expect to receive reasonable compensation for their professional services and materials used to care for the health of their patients. Unlike the human health care system, there is not a well-established network of pharmacists or other 3rd-party individuals that are trained, licensed, and experienced in dispensing antimicrobial drugs for use in animals. As such, veterinarians play a vital role as educated dispensers of veterinary drugs in North America, Europe, and other parts of the world that cannot be readily replaced. There are no other currently available mechanisms for controlled distribution of antimicrobial drugs, and the Committee strongly believes that veterinarians can and do act in an ethical manner regarding prescribing and dispensing of antimicrobial drugs.

Recommendations

General Recommendation

The Committee recommends that *voluntary* actions be taken by the veterinary profession to promote conservative use of antimicrobial drugs to minimize the potential adverse effects on animal or human health. We do not believe that regulatory action is needed to reduce availability of antimicrobial drugs to veterinarians. However, we do believe that it is appropriate to require that antimicrobial drugs applied in animals are restricted to use by a veterinarian or on their explicit order. More specific recommendations that are endorsed by the Committee to promote conservative application of antimicrobial drugs in animals are listed below.

Recommendation A

The Committee recommends that the sale of antimicrobial drugs for use in all animals be restricted such that these drugs are only used by a veterinarian or in accordance with their explicit order. (Note: ''Antimicrobial drug use in accordance with a veterinarian's explicit order'' refers to use by nonveterinarians according to the explicit verbal or written instructions of their veterinarian or through issuance of a valid prescription, in the same manner that antimicrobial drug use is restricted for use in humans in the United States and other countries. Specifically, this does not preclude veterinarians from dispensing antimicrobial drugs directly to clients for use in their animals.) This is not a new issue, and it has been addressed previously in panels and discussion forums.[29] It is hard to reconcile restricting the sale of antimicrobial drugs licensed for humans to prescription only, while allowing the sale of some of the same drugs in animals without approval of a veterinarian. The Committee believes that wise, conservative use of antimicrobial drugs requires a sophisticated, integrated understanding of preventive medicine, internal medicine, microbiology, and pharmacology, as well as a thorough understanding of animal management. Veterinarians are uniquely trained to provide expertise in these disciplines. Therefore, to promote judicious use, antimicrobial drugs should only be used in animals under the direction of a veterinarian. Scientific data are not available showing that use of antimicrobial drugs without veterinary prescription or veterinary supervision has had an effect on the prevalence of resistance any more than it might have if the drugs were only available by veterinary direction. It is true that the antimicrobial drugs that health professionals are most concerned about are the more advanced, newer drugs that are only available by prescription in most countries. However, inappropriate use of other drugs has the potential to increase the prevalence of resistance that would necessitate increased use of a higher category of drugs. Given the serious potential consequences of diminished clinical efficacy of antimicrobial drugs, the Committee believes that conservative use should prevail. As such, the Committee recommends that veterinary organizations and regulatory bodies promote prescription-only dispensing for antimicrobial drugs used in animals, including birds and fish. This includes restricting legal sales of preparations currently available without prescription, as well as increasing restrictions and consequences associated with illegal sale and importation of prescription antimicrobial drugs from foreign countries or other black market sources.

Recommendation B

The Committee believes that veterinarians, because of their unique and specialized training, are the individuals best able to make recommendations regarding the use of antimicrobial drugs in animals, both from a policy perspective as well as with regard to specific animal populations or individuals (assuming that veterinarians have established veterinarian-client-patient relationships).

Any treatment of animals by owners or their agents should be carried out in full accordance with orders provided by veterinarians responsible for the health of these animals. Veterinarians should encourage owners to follow all recommendations completely, especially in regard to dose, frequency, and duration of treatment with antimicrobial drugs, but also in regard to prevention and supportive care. Furthermore, we recommend that owners and managers always seek veterinary advice before initiating treatment with antimicrobial drugs in animals, which would be an implicit requirement if antimicrobial use in animals was restricted to a prescription-only basis. Expert advice from veterinarians (including those experienced in clinical practice) should always be sought when developing policy or legislation regarding antimicrobial use or availability.

Recommendation C

The Committee commends the work performed by many veterinary organizations to promote conservative use of antimicrobial drugs and recommends that all veterinarians study and apply the science-based principles of judicious use endorsed and promoted by many veterinary organizations.[5]

Recommendation D

The Committee strongly recommends that veterinarians assist in developing formal infection control plans for all facilities in which animals are reared or managed, including all veterinary hospitals or clinics. The Committee strongly recommends that veterinary organizations assist veterinarians by developing resources to aid in the development of tailored disease control plans.

The 1st step in decreasing use of antimicrobial drugs is to decrease the risk of bacterial infections when possible. The most effective means of reducing this risk is to use effective prevention practices for infectious diseases. It is easy to become overwhelmed with the details of treating disease to the point at which disease prevention efforts are not given a priority in disease management. One way to bring prominence to disease prevention efforts is to develop formalized recommendations for disease control at animal premises and veterinary facilities.

It is important to realize that infection control plans are relevant for all types of animal facilities: for small and large animals, pleasure and business operations, rural agriculture facilities, and urban situations, among others. Infection control plans are especially important for complex operations with large or transient populations of animals, but it is also important to have infection control plans for households with only a few pet animals. Infection control and hygiene should be considered in the management of all animals and should be discussed with all clients. These infection control plans must go beyond vaccination and deworming programs. Veterinarians should educate owners and managers about increases in disease risk whenever their animals contact other animals through travel, showing, or introduction of new animals to the premises (regardless how long they stay).

Although this might seem to be an obvious and simple recommendation, the practicalities of formalizing and instituting such policies will have a marked effect on day-to-day activities. Daily routines must be characterized and standardized. These include, but are not limited to, cleaning procedures, disinfection practices, animal and personnel movement, personal hygiene, routine housing practices, isolation and quarantine practices, and waste disposal. In addition, protocols must be developed to manage uncommon situations or emergencies when they arise, such as disease outbreaks. Exact recommendations will need to be tailored to individual premises and different animal populations. Veterinarians are uniquely qualified to assist with tailoring plans for specific populations and needs of owners and should use this opportunity to market their talents.

Recommendation E

Veterinarians should identify common case scenarios in which antimicrobial drugs are often employed (eg, respiratory disease) and develop standardized antimicrobial drug use recommendations tailored for use in their practices. In addition, the Committee recommends that the ACVIM and other veterinary organizations should commission experts to develop clinical practice guidelines addressing important animal diseases commonly seen in veterinary practice.

The factors that should guide decisions regarding how antimicrobial drugs are used should first and foremost include objective data regarding efficacy, toxicity, and predisposition for use, to affect the prevalence of resistant bacteria in target and bystander bacterial populations, and information regarding importance of specific drugs for human health care.[30] In the absence of these specific data, caution is warranted to ensure appropriate consideration for the safety of specific patients and the well-being of the larger animal and human populations. For many case scenarios that are commonly encountered, it would be most efficient and help to ensure consistency if practicing veterinarians formally considered and standardized antimicrobial uses that they will employ for typical case presentations. These antimicrobial drug use plans can be incorporated into infection control plans for veterinary practices and other animal facilities. Veterinarians should evaluate these antimicrobial regimens to ensure that they are minimizing use where possible and using antimicrobial drugs wisely whenever they are used. Antimicrobial drug use plans for a specific practice or for groups of practices can be developed that encourage the formation and use of infection control committees whose job is to decrease the risk of hospital-associated infections and to decrease the consequences of these infections when they occur. Developing use policies for antimicrobial drugs and monitoring programs for emerging antimicrobial resistant pathogens in the hospital environment is a logical aspect of this task.

Practice guidelines have become an important tool for physicians that use evidence-based medicine in practice[31] and would be a welcome source of information to veterinarians as well. Practice guidelines are typically prepared by 1 or more clinical and diagnostic experts to assist practitioners in making decisions about appropriate health care for specific clinical circumstances. The intent is to improve appropriateness of care, improve cost effectiveness, and serve as educational tools. These are *not* intended to dictate standards of practice or detract from the ''art'' of veterinary medicine. Rather, they are intended to ensure that the art of medicine is applied on a solid, scientific basis. They will typically address various aspects of disease management, such as diagnosis, treatment, nursing care, and nutrition, that are pertinent for a specific clinical conditions.[32] To be most useful, these guidelines should be evidence based and scientifically valid. However, practice guidelines are intended to enhance clinical decision-making and should therefore never be a substitute for clinical discretion and judgment. These guidelines will inherently be broad based because no guideline can ever be specific enough to be applied in all situations. Examples of specific conditions for which clinical practice guidelines would be useful include, but are not limited to, the following: septicemia, infectious respiratory disease, gastrointestinal disease (including colitis, intestinal obstruction, diarrhea, and inflammatory bowel disease), major organ failure, and perioperative prophaylaxis for postsurgical infection in small and large animals; cancer, cystitis, otitis, and dermatitis in small animals; and failure of passive transfer of immunity or other health problems in large animal neonates. Ideally, practice guidelines are formulated by summarizing and only considering the most objective and valid published research. However, the body of published literature regarding some health conditions of animals is meager. The committee recommends that the veterinary profession promote the call for appropriate clinical trials and other objective scientific studies that are needed to strengthen recommendations that would be forwarded from clinical guidelines.

Recommendation F

To facilitate appropriate empirical selection of antimicrobial drugs on a routine basis, the Committee recommends that veterinarians categorize all antimicrobials used in their practice into Primary, Secondary, and Tertiary Use categories. The Committee recommends that veterinary associations foster communication with infection control and infectious disease specialists in human medicine to assist with classification of the relative importance of resistance associated with different antimicrobial drugs in humans.

These assignments would be made by practicing veterinarians relative to their individual practice circumstances and would *not* be formally made by licensing agencies or pharmaceutical companies. Drugs will be assigned to different use categories depending on the practice type and patient profiles (ie, a drug could be assigned to a more restrictive category in primary care and wellness practices but might be assigned to more permissive categories for emergency, critical care, or referral specialty care practices). Drugs assigned to the Primary Use category would include older drugs and those with a narrower spectrum of coverage (eg, simple penicillins, tetracyclines, sulfonamides). It is anticipated that these drugs will be used for the majority of infections. It is important to remember that Primary Use drugs are not necessarily less potent or less useful than other drugs and can be very appropriate for use in critically ill animals. Drugs assigned to the Secondary Use category include newer drugs with an extended spectrum of coverage compared with Primary Use drugs and those of added importance in the treatment of serious or frequently resistant infections in humans. Drugs for which antimicrobial resistance appears to develop relatively easily should also be included in this class. Secondary Use drugs should generally be reserved for use when culture and sensitivity results indicate that Primary Use drugs are not appropriate. Drugs that are very important for human and animal health care, especially those most recently developed and those that have extended spectra of coverage and are useful against the most resistant bacteria, should be classified for Tertiary use. Tertiary Use drugs should only be prescribed for animals with clinically important infections caused by bacteria that have been demonstrated to be resistant to all reasonable Primary and Secondary Use drugs. Veterinarians should also consider whether an antimicrobial drug's value to human welfare is so important that its use should be voluntarily prohibited in animals. Specifically, this voluntary prohibition should be considered for drugs that are not licensed for use in veterinary medicine and are very important for treating resistant infections in humans.

To determine whether the occasional use of antimicrobial drugs that are very important for human health care is warranted, veterinarians are encouraged to develop procedural guidelines that outline advantages and disadvantages of use according to the species of the patients, duration of use, and management that would reduce risk of transmitting resistant bacteria (if present) among in-contact people and animals. When developing treatment plans involving antimicrobial use, veterinarians should seek to employ drugs conservatively when possible before using drugs in a more aggressive manner. This includes considering use of local rather than systemic application when possible. *Higher category drugs should not be employed in place of primary or secondary drugs unless it is reasonable to believe that these drugs will provide meaningful aid to the recovery of patients. More specifically, these drugs should not be employed in patients that are likely to recover without treatment, in patients that are as likely to be helped through treatment with lower category drugs, or in patients that are unlikely to survive regardless of the therapeutic regimen.*

It is very important that Secondary or Tertiary category antimicrobial drugs not be used when a Primary category drug could be just as effective. Decisions to advance from a Primary category drug to a Secondary or Tertiary category drug should be based on culture and sensitivity information whenever possible or on inadequate response to therapy with a lower category drug after allowing sufficient time to evaluate response. Although it seems logical and practical that antimicrobial drugs should be used for some minimum amount of time before reaching a conclusion about failure to respond to treatment that would predicate a change in treatment plans (ie, change drugs, route, dose, etc), the Committee believes that science-based duration of treatment information is lacking that would allow evidence-based determination of this duration. This will obviously be affected by variation among patients in the adequacy of their defensive responses to infections, as well as by variation in pathogenicity among bacteria. The Committee recommends that further research be conducted in this area of patient management.

Veterinarians should consider instituting more rigorous patient management protocols whenever Secondary or Tertiary category drugs are employed. These protocols might include increased biosecurity and barrier nursing precautions to decrease the risk of direct and indirect transmission of resistant bacteria, careful management and disposal of waste and bedding materials, more vigorous cleaning and disinfection protocols, and specific client education regarding home premises biosecurity.

Recommendation G

The Committee recommends the submission of appropriate specimens for bacterial culture, pathogen identification, and susceptibility testing by standardized methods whenever possible to allow an evidence-based approach for drug selection.

Although this can increase the costs associated with patient care, other costs associated with improper drug selection (prolonged treatment, unnecessary use of expensive antimicrobial drugs, increased morbidity and mortality) can outweigh the cost of this testing. It is important to note that laboratory methods and standardized breakpoints still need to be established for numerous bacteria-drug combinations that are important to veterinary medicine. The ACVIM advocates that additional research be conducted to improve the veterinary profession's ability to make evidence-based decisions about antimicrobial drug use.

Recommendation H

The Committee recommends that selection of resistant bacteria through use of antimicrobial drugs should be considered an important potential risk associated with treatment. This potential outcome should not necessarily preclude use of antimicrobial drugs in animals that require treatment, but development of resistance should always be considered as an important potential sequela of treatment and avoided whenever possible.

The consequences of developing resistance should be considered most important when it is associated with drugs that are most important for human health care or bacteria that are resistant to multiple drugs. There are many potential routes of zoonotic transmission of resistant bacteria. Although foodborne transmission is frequently recognized for its potential importance, it is not necessarily more important than transmission facilitated by direct and indirect contact. Thus, resistance that emerged in companion animals could be as important a risk to human health as resistance that might emerge in food-producing animals. And although large animals might have a greater potential to contribute to environmental contamination with resistant fecal organisms compared with small animals, emergence of resistance in small animals is still of concern because these animals often share home environments with people.

Antimicrobial drugs will always need to be used empirically in some patients on the basis of previous experience and knowledge of the agents that are most likely to be recovered from a particular species with disease in a particular organ system. Initial empirical treatment should rely on drugs assigned to the Primary Use category, not in Secondary or Tertiary Use categories, unless specific evidence suggests that Secondary or Tertiary category drugs are needed. Response to treatment should always be used in evaluating the success of this drug treatment, but changes in treatment regimens should be based on culture and susceptibility information as much as possible.

Recommendation I

The Committee believes that prophylactic and metaphylactic use of antimicrobial drugs is appropriate for control and prevention of infectious diseases in animals. However, as is true for all uses of antimicrobial drugs, treatment in the absence of clinical disease should be conservative and should emphasize drugs assigned to the Primary Use category, except in situations in which specific information suggests that Secondary or Tertiary category drugs are needed.

Veterinarians should reserve prophylactic or metaphylactic use for high-risk situations in which research or clinical experience has clearly shown that these applications provide measurable clinical benefit. The Committee recommends that further research be conducted to objectively evaluate the effectiveness of common prophylactic antimicrobial drug uses in veterinary medicine. Veterinarians should consider whether animal husbandry situations in which excessive problems with infectious diseases require frequent or repeated prophylactic or metaphylactic use of antimicrobial drugs constitute objectionable violations of animal welfare standards.

It is not necessary to use antimicrobial drugs in all surgical cases to prevent infections. It is possible to effectively minimize the likelihood of postoperative infections by vigorously promoting aseptic technique, minimizing surgical time, and minimizing tissue manipulation. This is especially true for clean surgeries, as opposed to clean-contaminated or contaminated procedures, as classified by the National Academy of Sciences.[33] Objective evaluations of human surgical patients have allowed formulation of clinical practice guidelines regarding prophylactic antimicrobial use in surgical patients.[34,35] The Committee recommends that the American College of Veterinary Surgeons or other expert groups work to develop practice guidelines regarding antimicrobial prophylaxis in veterinary surgical patients and to pursue research on techniques that would reduce the use of antimicrobial drugs as well as decrease the risk of surgical complications. Similarly, antimicrobial prophylaxis is not needed for all patients with indwelling catheters or those undergoing invasive diagnostic procedures. Rigorous use of aseptic technique and precautions known to minimize risk of local infections can eliminate the need for antimicrobial drug treatment for these procedures in most patients. Prophylaxis is appropriate in some patients that have a diminished ability to appropriately respond to bacterial infections, such as those with acquired immune dyscrasias, those treated with immunosuppressive medications, or animals with other serious illnesses. However, the Committee strongly believes antimicrobial prophylaxis is not needed or recommended for all patients with these conditions. Clinical judgment will be needed to evaluate individual cases to assess the likelihood of benefit from antimicrobial prophylaxis. The Committee recommends that practice guidelines be developed to assist practicing veterinarians with decisions about conservative use of antimicrobial drugs in these situations.

Recommendation J

Diagnostic laboratories that test samples obtained from animals through testing and reporting policies can have a major effect on antimicrobial use practices of client veterinarians. As such, the Committee recommends that veterinary diagnostic laboratories develop standardized protocols regarding laboratory procedures and reporting of results for bacterial cultures and susceptibility testing.

Bacteriology laboratories should consider refraining from reporting isolation of normal flora in normal numbers occupying a normal biological niche. If the bacterial growth cannot be distinguished from normal flora by its species identification, by identification of specific virulence factors or correlated markers, or by clear demonstration of overgrowth, laboratory reports should clearly indicate that their presence in samples could be considered normal. For example, a report stating ''normal flora isolated'' or ''no *Salmonella* isolated'' is less likely to generate a request for unneeded susceptibility testing than a report noting ''numerous *E coli* isolated.'' Antimicrobial susceptibility should generally not be reported for these normal flora, and testing might not be necessary for specific pathogens with predictable susceptibilities or proven specific treatments with a high likelihood of efficacy.[36] Decisions regarding which bacteria should be selectively tested and reported should be made by the clinical microbiologist in conjunction with the veterinarian and other relevant professionals, such as pharmacists or the infection control committee for a hospital.[37]

Although in many cases clinical microbiology laboratories use broad, standardized panels of antimicrobial drugs when testing susceptibility in a variety of bacterial isolates, it is the responsibility of the laboratory to limit the results reported to those drugs appropriate to the bacterium, the animal species of the patient, and the site of infection. The spectrum of drug susceptibility results reported should be appropriate to the setting and could be different for animals seen by primary caregivers and referral centers. Guidelines published by the National Committee for Clinical Laboratory Standards provide suggestions for the most appropriate drugs to be tested for the major bacterial pathogens, in additional to rational guidelines for selective or cascade reporting of susceptibility information for higher order drugs if resistance is detected to the Primary Use drugs.[37]

Bacteriology laboratories should routinely test certain bacteria for resistance patterns that are of compelling concern in human and veterinary medicine. For example, *S aureus* isolates should be tested for methicillin resistance when indicated, and enterococci should be tested for vancomycin resistance. These results should not be reported unless resistance is noted to alternative, lower priority drugs. Bacteriology laboratories should communicate with infection control and infectious disease specialists in veterinary medicine to monitor the emergence of specific multidrug-resistant organisms such as vancomycin-resistant enterococci and methicillin-resistant *S aureus.*

Recommendation K

Monitoring and surveillance are an important part of any control program because they provide feedback on the status of the program. As such, the Committee recommends that the monitoring of antimicrobial drug use and surveillance for trends in the prevalence of resistant bacteria be promoted as important tools for the veterinary profession. This should include active surveillance for dissemination of pathogens both within and between populations of different host species (including humans). In addition, the Committee recommends that veterinary organizations urge the federal government fund the development of a national system for monitoring antimicrobial drug use in humans and animals.[2]

Monitoring and surveillance will allow antimicrobial drug use to be evaluated at various levels of the veterinary profession: within practices, within practice specialties, regionally, and even nationally. Individual veterinary practices should devise methods for recording and periodically (eg, quarterly, semiannually, or annually) summarizing antimicrobial use data. These data should be reviewed and compared with antimicrobial use protocols (described above) to identify drug use that appears to be inconsistent or of concern. This is especially important for large, complex veterinary practices. Surveillance for epidemics of resistant bacteria will allow assessment of the underlying causes of changes in resistance prevalence and in some cases will help to identify specific problems with biosecurity and infection control.

The Committee also recommends that veterinary organizations call for expansion of national systems for monitoring antimicrobial susceptibility to include important animal pathogens and that diagnostic laboratories and veterinary practices strive to develop uniform methods for testing and reporting susceptibility information, including regular summarization and reporting of susceptibility information to veterinarians. Currently, national surveillance efforts for antimicrobial susceptibility target a few human and zoonotic pathogens, especially foodborne pathogens. Susceptibility of other agents is only evaluated through smaller investigations that often use different investigation methods, making it difficult to extrapolate among studies. Expanding current surveillance efforts to include important animal pathogens (such as *M haemolytica* collected from cattle with respiratory disease or *S aureus* and *E coli* collected from small animals with dermatitis or cystitis) would provide important information about the ability to emphasize drugs in the Primary Use category, as well as the prevalence of resistance to important antimicrobial drugs.

On a smaller scale, active and passive surveillance should be employed whenever possible to enhance early detection of transmission and amplification of resistant bacteria in animal populations. This is especially critical in larger animal populations and in veterinary hospitals and clinics. Veterinarians should record susceptibility information for their practices and compare these data with those collected nationally, as well as locally or regionally. These susceptibility data should be compared with antimicrobial use summaries, as well as antimicrobial use protocols. It is important that these data be categorized by treatment history so that data collected from animals after they have been treated with an antimicrobial drug do not bias data intended to represent pretreatment susceptibility data for animal pathogens. Routine monitoring of animals treated with higher category drugs (Secondary or Tertiary) should be given a priority in order to detect emergence of bacterial resistance to these important drugs. Veterinary practices should consider including monitoring of bacterial susceptibility data for all isolates obtained from animals with nosocomial or postoperative infections. It might also be useful to institute routine culture of environmental samples obtained in areas in which patients treated with Tertiary category drugs are managed or housed.

Recommendation L

Education is an essential cornerstone of the veterinary profession. The Committee believes that increasing educational efforts regarding antimicrobial resistance and conservative antimicrobial drug use will be critical for the success of efforts aimed at mitigating the hazards associated with emerging antimicrobial resistance.

These efforts should be targeted at all levels of the veterinary profession (veterinary students, practitioners, interns, residents, and specialists), as well as owners and managers of animals. The Committee believes that conservative use of antimicrobial drugs requires that veterinarians become more sophisticated in their understanding of pharmacology and microbiology to most appropriately apply antimicrobial drugs. Efforts such as the Veterinary Antimicrobial Decision Support System, which is designed to assist veterinary practitioners in making the best possible decisions about antimicrobial use, have the potential to greatly facilitate these efforts.[38] Development of this and other tools is highly encouraged to aid appropriate decision making by busy veterinarians. In addition, the ACVIM and other veterinary organizations should sponsor in-depth seminars on this topic, and veterinary colleges should ensure that students graduate with a sophisticated understanding of factors affecting choice of antimicrobial drugs. The Committee urges veterinary colleges to ensure that, in addition to pharmacologic information, judicious use of antimicrobial agents is prominently covered in veterinary curricula. Efforts to ensure uniform coverage of this material within the curricula of veterinary schools and colleges is highly encouraged, such as the recent programs endorsed by agencies within the US Department of Health and Human Services.[39]

Recommendation M

The Committee recommends that the ACVIM and other veterinary organizations encourage pharmaceutical companies to market drugs on the basis of scientific information about efficacy and adverse treatment outcomes (including promotion of resistance in bacteria). Furthermore, the Committee recommends that veterinary organizations encourage the pharmaceutical industry to follow the example of their industry leaders in promoting conservative antimicrobial drug use in veterinary medicine.

Advertising can markedly influence use and prescription patterns for antimicrobial drugs. This is why pharmaceutical companies invest in this type of marketing. Although not universal, there are numerous examples of advertisements for antimicrobial drugs that appeal more to emotion than to science in attempting to influence prescription patterns.

Recommendation N

The Committee recommends that governmental and nongovernmental funding agencies prioritize research regarding antimicrobial use, antimicrobial resistance, alternatives to antimicrobial treatment, and infection control practices. There is a dearth of information regarding factors that are associated with development of antimicrobial resistance in bacteria from animals and the risks of antimicrobial resistance in veterinary isolates on animal and human health.[1,2]

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Appendix

Committee members were members or officers in the following professional organizations at the time that this statement was prepared. *Board Certification:* American College of Veterinary Internal Medicine (LAIM and SAIM), American College of Veterinary Clinical Pharmacology, and American College of Veterinary Microbiology. *Service Roles Related to the Panel's Charge:* the American Veterinary Medical Association (AVMA) Steering Committee on Antimicrobial Resistance, the National Committee on Clinical Laboratory Standards, Veterinary Antimicrobial Susceptibility Testing Sub-Committee, the ACVIM Infectious Disease Study Group, and the United States Pharmacopeia. *Members or Officers in Professional Associations:* American College of Veterinary Internal Medicine, American College of Veterinary Clinical Pharmacology, American College of Veterinary Microbiology, AVMA, Canadian Veterinary Medical Association, American Animal Hospital Association, American Association of Equine Practitioners, American Association of Bovine Practitioners, American Association of Swine Veterinarians, Academy of Veterinary Consultants, Association for Veterinary Epidemiology and Preventive Medicine, International Society for Veterinary Epidemiology and Economics, American Association of Veterinary Laboratory Diagnosticians, American Society for Microbiology, American Academy of Veterinary Pharmacology and Therapeutics, US Animal Health Association, International Association for Food Protection, Poultry Science Association, Veterinary Infection Control Society, and numerous state, provincial, and local Veterinary Associations.