Article

Antimicrobial dispensing by Ontario dairy veterinarians

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Abstract — This questionnaire-based cross-sectional study was designed to capture the demographics of dairy practitioners in Ontario and to describe aspects of antimicrobial dispensing on-farm and over-the-counter by these veterinarians. The information collected revealed that the prescription status of a drug and the level of veterinary-client-patient relationship were important elements of dispensing policies. Over-the-counter dispensing records were incomplete, while only a small proportion of on-farm dispensing records contained pertinent information and directions as required by the *Veterinarians Act.* While respondents recognized that antimicrobial use in dairy herds could lead to resistance in cattle, few indicated that this was a significant public health issue. Veterinarians can play a key role in antimicrobial stewardship, part of which is the provision of complete written dispensing instructions to producers for antimicrobial use in dairy cattle.

Résumé — La distribution des agents antimicrobiens par les vétérinaires qui s'occupent des vaches laitières en Ontario. Cette étude en coupe transversale a été réalisée à partir de réponses recueillies d'un questionnaire qui ciblait les données démographiques des praticiens des fermes laitières de l'Ontario en plus de décrire les habitudes de dispense des doses d'agents antimicrobiens in situ par les vétérinaires ou en vente libre auprès des distributeurs. Cette information nous a permis de reconnaître que le statut de l'agent antimicrobien prescrit et le niveau de relation entre le vétérinaire-client-patient sont des éléments très importants de la politique de dispense. Les données concernant les agents antimicrobiens achetés sans prescription étaient incomplètes dans les points de vente et seulement une petite proportion des données internes à la ferme contenait les informations et les dosages tels que requis par la loi sur les vétérinaires. Les répondants reconnaissaient que l'utilisation des agents antimicrobiens chez les vaches laitières pouvait élever leur résistance à ceux-ci, mais peu d'entre eux mentionnaient que ceci engendrait une réelle inquiétude pour la santé publique. Les vétérinaires ont donc un rôle clé à jouer et ils devront être assidus en fournissant, par écrit, des instructions complètes sur les prescriptions d'agents antimicrobiens aux producteurs de vaches laitières.

(Traduit par les auteurs)

Can Vet J 2015;56:723–729

Introduction

Concerns regarding the potential public health impact of resistant bacterial infections of food-animal origin resulted in calls for more prudent use (1–3). This has in turn spawned the development of guidelines and policy recommendations regarding the use of antimicrobials by veterinarians and producers (4–8). Common elements among these guidelines include: the need for a valid veterinarian-client-patient-relationship (VCPR); justifiable antimicrobial treatment and selection; the need for written (*versus* verbal) treatment protocols and dispensing records; the promotion of husbandry practices that will have a sparing effect on antimicrobial use; and on-going veterinary and producer continuing education regarding antimicrobial use and resistance. Antimicrobial drugs are used in the conventional management of dairy herds (9,10); there was a lack of information on antimicrobial dispensing by veterinarians. The purpose of the current study was to collect baseline information on antimicrobial use in Ontario free-stall dairy herds in 2001.

Although not specifically tied to the issue of antimicrobial resistance, concerns associated with on-farm food safety have contributed to the development of a quality assurance program by the dairy industry. The Canadian Quality Milk (CQM) program is a HACCP (Hazard Analysis Critical Control Points)-based program that outlines best management practices linked to the prevention of specific hazards, with a section specific to managing drug use on farms to avoid residues in milk and meat

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(11). Industry initiatives like CQM and the Livestock Medicines Education Program (12) are intended to encourage proper handling and administration of drugs on-farm.

Antimicrobials vary in their importance based on their ability to treat severe bacterial infections. The Veterinary Drug Directorate has categorized animal antimicrobials according to their importance to human medicine. It is noteworthy that ceftiofur, a 3rd generation cephalosporin, is in Category I (very high importance to human medicine), while penicillin-G is in Category II (high importance) (13). Both of these antimicrobials are commonly used in dairy medicine and their differences should be considered when selecting antimicrobial drugs.

This study was the first of its kind at the time and had the following objectives: provide demographic information for dairy practices and practitioners in the Province of Ontario; collect data on factors that could influence antimicrobial selection, dispensing and use; describe aspects of communications and record-keeping associated with antimicrobial dispensing; and ascertain the attitudes regarding antimicrobial resistance in an animal health and public health context.

Materials and methods

Sampling frame

The population of interest for this study was veterinarians in the province of Ontario who practice dairy medicine. A sampling frame of veterinarians (n = 340) was developed from a list of practices (n = 240) accredited as "Food-Producing Animal Mobile" by the provincial veterinary licensing body, the College of Veterinarians of Ontario (CVO). The CVO registry did not categorize practices or members by species focus. Individual veterinarians from these practices were identified using the CVO 2001 Directory. To further characterize the response rate, veterinary practices were sub-categorized in the sampling frame as Dairy Intensive (practices with 1 or more veterinarians committed to full-time dairy practice, n = 48 practices) based on known practice profiles and the species focus of individual practitioners (n = 117) within those practices. To limit design-based selection bias, in the form of non-response bias, all non-respondents were contacted with equal rigor through follow-up telephone reminders.

A questionnaire (described elsewhere, 14), designed to elicit information about antimicrobial use by dairy veterinarians, was pre-tested by 12 practitioners and refined. On July 2, 2001 questionnaires were mailed to 240 practices. There were no incentives in place to motivate participation. Over the 6-month period following the initial mailing, practices with non-respondents were contacted by telephone to remind those practitioners to complete and submit their surveys.

The questionnaire was self-administered and contained 4 sections focusing on respondent and practice demographics, antimicrobial dispensing considerations and communications, antimicrobial drug use, and opinions regarding antimicrobial use and resistance. Practitioner demographic information included the veterinary school year of graduation, the proportion of total professional activity dedicated to dairy practice, and the amount of time spent on different aspects of dairy production medicine.

The body of the questionnaire focused on aspects of antimicrobial use pertaining primarily to lactating cow treatments. Attitudes regarding antimicrobial use were investigated with questions about dispensing policies and the veterinarian-client-patient-relationship, factors influencing drug selection, the use of written (pre-printed or written at the time of visit) on-farm protocols, drug-use information sources, the records associated with antimicrobial drug dispensing on-farm and over-the-counter, and the impact of antimicrobial drug use by the dairy industry on antimicrobial resistance in dairy cattle and humans.

Questionnaire data were stored in a relational database (Microsoft® Access 2000). Descriptive analysis was conducted using statistical software; Fishers exact test, Chi-squared, f-test and t-test statistics (two-sided) were used to evaluate univariable associations between demographic variables, and were considered significant at $P < 0.05$ (SAS version 9.1.2; SAS Institute, Cary, North Carolina, USA). To assess associations between over-the-counter (OTC) dispensing policies for antimicrobials of different prescription status) and the level of veterinarian-client-patient-relationship (VCPR), a mixed multivariable logistic regression model (PROC GLIMMIX) was created that controlled for extraneous respondent and practice demographic factors. Given the small number of predictor variables of interest, all were admitted to the full model. Spearman's rank correlation coefficients were examined for pairwise correlations among predictor variables > 0.7 to avoid collinearity between model covariates. Model building was done manually through an iterative process in which variables were retained based on evidence of confounding, which was a substantive change ($> 20\%$) in coefficients of the explanatory variables of interest (antimicrobials of different prescription status and VCPR), based on a significance level of $P < 0.05$, and also if they were part of an interaction term. Continuous variables (years in practice; percent time spent on individual cow medicine; percent time spent on dairy practice; number of dairy clients; and percent revenue from drug sales) were examined for linear relationships with the outcome, OTC, by assessing quadratic terms and hierarchical dummy variables, and also using a lowess curve. To account for a practice effect in the model, PracticeID was included as a random intercept. Interactions among all terms in the main effects model were examined for significant associations with OTC dispensing. Finally, Chi-square tests were used to evaluate the questions regarding the impact of antimicrobial drug use by the dairy industry on antimicrobial resistance, and these questions were dichotomized from the original 5-point scale (strongly agree to strongly disagree) into the following categories: strongly disagree, disagree, and no opinion *versus* agree and strongly agree. A Fisher's exact test was used to evaluate potential associations between the opinion questions on the animal and human health impacts of antimicrobial use in cattle and the frequency with which a respondent was concerned about AMR in selecting an antimicrobial.

Results

Two hundred and sixty-four veterinarians remained in the sampling frame once those indicating dairy practice was "not a duty" were removed. The response rate was 47% (124/264).

Table 1. Summary of respondent and practice demographics of a survey applied to 264 Ontario dairy veterinarians from 240 practices in July 2001

Number (%) of respondents	124		(47)
Number (%) of respondent practices	83		(35)
Median (range) years in practice	19		(0.25 to 50)
Number (%) of OVC[a] graduates	117		(94)
Number (%) of female respondents	11		(9)
Number (%) of respondents practicing in each Ontario region:			
Southwestern	69		(56)
Southeastern	33		(27)
South-central	15		(12)
Northern	7		(6)
Number (%) of respondents, % professional time spent in dairy practice:			
> 75%	50		(40)
51% to 75%	34		(27)
26% to 50%	19		(15)
1% to 25%	21		(17)
% respondents active in different aspects of dairy practice, and the average % (range) practice time spent on those activities:			
Individual cow medicine and surgery (ICM)	95	40	(0 to 100)
Reproduction	98	38	(0 to 100)
Milk quality and udder health	85	7	(0 to 30)
Feeding and nutrition	72	6	(0 to 40)
Replacement heifer management	73	4	(0 to 20)
Facility planning	38	1	(0 to 10)
Financial consulting	15	0.4	(0 to 15)
Number (%) of respondent practices in practice size categories:			
< 26 farms/practice	24		(29)
26 to 50 farms/practice	24		(29)
51 to 75 farms/practice	15		(18)
76 to 100 farms/practice	10		(12)
> 100 farms/practice	11		(13)
Median (range) number of dairy herds per practice	45		(1 to 250)
Median (range) percentage of practice herds milking:			
< 50 cows	59%		(0 to 100)
51 to 100 cows	36%		(0 to 100)
> 100 cows	4%		(0 to 29)
Median % (range) herds per practice with free-stall barns	20%		(0 to 83)
Median % (range) gross practice revenue from drug sales	43%		(1 to 100)

[a] OVC — Ontario Veterinary College, University of Guelph, Guelph, Ontario, Canada.

Respondent demographics are summarized in Table 1. The response rate in each region was reflective of the provincial distribution of the dairy industry, with most respondents practicing in either southwestern or southeastern Ontario (Table 1). There were 83 practice locations: 42 in southwestern Ontario, 20 in southeastern Ontario, 15 in south-central Ontario, and 6 in northern Ontario. The number of respondents per practice ranged from 1 to 5, but in most cases there was only 1 (70%) or 2 respondents (18%) per practice. Seventy-three percent of the practices were categorized as dairy intensive and 57% of the veterinarians in these practices responded to the questionnaire.

Respondents to our questionnaire were Ontario dairy practitioners, predominantly male graduates of the Ontario Veterinary College with 11 to 24 y in practice (median time in practice = 19 y). Eleven female veterinarians (9%) responded (Table 1). There were no significant differences in the distribution of female and male respondents among the other demographic variables with the exception of the percentage of professional time spent in dairy practice, where most of the female respondents (9/11) spent < 50% of their professional time engaged in dairy practice compared with 68% of males spending > 50% of their time in dairy practice (Fisher's exact test, $P = 0.0006$).

The number of dairy clients per practice was evenly distributed across the other categories with 48% of respondents serving 50 farms or less. There were no significant regional differences in the proportion of small, medium, and large herds across regions (f-test, 3 df, $P > 0.05$). Practices across the province indicated the majority of herds they attended milked 50 cows or less and a relatively small percentage of herds milked more than 100 cows (Table 1). Response rate to the question regarding dairy practice gross revenue was 80% (99/124). Specifically, this questionnaire asked respondents to estimate the percentage of their dairy practice gross revenue that was derived from drug sales and professional fees; the median for this estimate was 43% (with an interquartile range of 15%).

From the client-type profiles provided by respondents in terms of level of Veterinarian-Client-Patient-Relationship (VCPR), the overall median values were as follows: 80% "regular clients" (farm visited every 2 to 8 wk), 15% sporadic clients (1 to 5 visits/y), and 0.5% rare clients (< 1 visit/y). A qualitative assessment of the data indicated within-practice variation among responses from multi-respondent practices; data, at the individual respondent-level indicated a higher frequency of OTC dispensing for both antimicrobials for regular clients (76% for penicillin, 69% for ceftiofur), followed by sporadic clients (51% and 38%, respectively) and finally a very low frequency for rare clients (21% and 8%, respectively). For regular clients, most of the respondents indicated a policy of OTC dispensing for both antimicrobials, with 24% and 31% requiring some form of veterinary consultation prior to dispensing penicillin or ceftiofur, respectively. After removing "NA" (not applicable) responses, 25% and 32% of respondents indicated they would not dispense penicillin or ceftiofur, respectively, OTC to any dairy producer, while 20% and 7% indicated they would dispense these antimicrobials without any form of veterinary consultation regardless of the level of VCPR.

A mixed multivariable logistic regression model indicated that OTC dispensing policy was associated with the type of antimicrobial being dispensed and VCPR client type, while controlling for the other demographic confounders in the model. The odds of procaine penicillin G being dispensed OTC were 4.6 times greater compared to ceftiofur [95% confidence interval (CI): 2.5, 8.6; $P < 0.0001$]. Regular clients were 26.3 times more likely to receive antimicrobials OTC compared to sporadic clients (95% CI: 10.9, 63.7; $P < 0.0001$), and the odds of OTC dispensing to sporadic relative to rare clients were 16.7 times greater (95% CI: 8.3, 33.3; $P < 0.0001$). Relative to respondents with a percent time spent on dairy practice < 26%, those with higher percentages of time spent in dairy practice were significantly more likely to allow OTC dispensing without requiring a veterinary consultation [26% to 50% time spent on dairy practice, odds ratio (OR) = 5.9; 95% CI: 1.4, 24.3; $P = 0.01$; 51% to 75% time spent on dairy practice, OR = 12.3; 95% CI: 3.6, 42.7; $P < 0.0001$; > 75% time spent on dairy practice, OR = 7.3; 95% CI: 2.2, 24.3; $P = 0.001$]. The odds of OTC dispensing were 5.2 times greater among respondents with less than 10 y in veterinary practice compared with their more experienced counterparts (95% CI: 2.2, 12.4; $P < 0.001$).

Respondents provided a ranking of the relative frequency with which they consulted different sources of information regarding antimicrobial drug use in lactating cows. Continuing education seminars, veterinary journals, and pharmaceutical company representatives were cited as primary information sources and were ranked the highest, while the Internet was ranked the lowest. The second tier of information sources included veterinary colleagues, laboratory tests, and the Compendium of Veterinary Products, followed by provincial government publication and specialist advice. Among the lower ranking sources were the Veterinary Drugs Directorate (VDD), the gFARAD (global Food Animal Residue Avoidance Databank) system, and other sources (product labels and clinical experience).

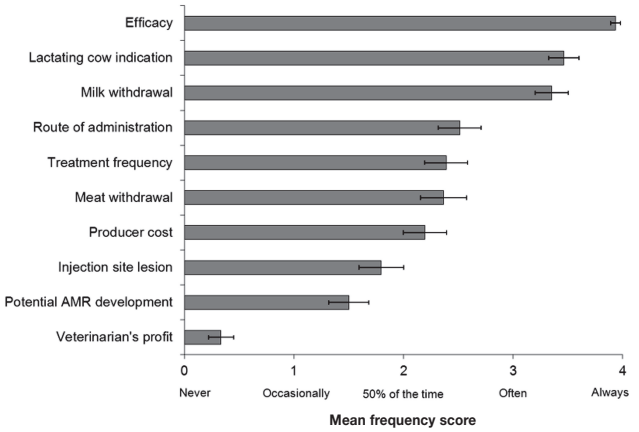

Figure 1. Mean frequency scores and 95% confidence intervals for considerations in selecting an antimicrobial treatment in a lactating cow as provided by 124 respondents to the survey administered to 264 Ontario dairy practitioners in July 2001. AMR – Antimicrobial resistance; Error bars depict 95% confidence limits for the mean frequency scores (SAS, Proc Means).

Among different factors considered in choosing an antimicrobial treatment for a lactating cow, a drug treatment's efficacy for the given condition ranked the highest, in terms of mean frequency score (Figure 1). Having a label indication for lactating dairy cattle and the milk withdrawal time for the drug were reported to be the next most frequent considerations in choosing an antimicrobial. Most indicated that potential injection site lesions and antimicrobial resistance development were only occasionally considered. Mean frequency scores for veterinarian's profit were low, with the majority indicating this was never (72%) or only occasionally (22%) considered in antimicrobial selection.

Thirty-four respondents (28%) indicated they provided their dairy clients with antimicrobial drug use protocols for lactating cows. Several respondents commented that protocols were not provided frequently, nor were they provided to all clients. In reporting how antimicrobial use instructions were provided to dairy producers 88% of respondents indicated that they wrote instructions for clients "often" or "always," of those, 40% indicated that they "always" left some form of written record. The "other" forms of treatment instruction included written instructions on the milk house white board, written instructions in the herd book, or written treatment sheets and protocols. Regarding record quality, the information most frequently included in an OTC record was the drug name (79%), the date (75%), and amount dispensed (73%), but information about the case and treatment specifics, including residue avoidance instructions were cited at frequencies < 20%. Twenty-seven percent of the veterinarians provided complete records when dispensing on-farm; however, none of the respondents provided a complete OTC dispensing record.

There was a greater proportion of veterinarians (81%) who responded to our questionnaire who agreed to the question "Do you feel antimicrobial drug use, at the current levels within the dairy industry, is a contributor to decreased antimicrobial efficacy in dairy cattle" compared with those who did not

agree (18%) (Chi-squared = 48, 1 df, $P < 0.01$). In contrast, 86% of respondents indicated some level of disagreement or no opinion, compared with the proportion that agreed, to the question asking whether antimicrobial use in dairy cattle could contribute to resistance in human medicine (Chi-squared = 64, 1 df, $P < 0.01$); of these, 27% indicated no opinion (data not shown).

Discussion

The demographic statistics for veterinary respondents and practices mirrored the distribution of dairy operations in the province and regional milk production statistics for 2001 (15). In surveys conducted by the Ontario Veterinary Medical Association (OVMA), median drug revenue for mixed and large animal practitioners, excluding equine specialists, was found to be 45.7% of total revenue (Darren Osborne, Director of Economic Research, OVMA, personal communication, 2014) compared to the survey response median of 43% in this report.

The respondent demographics of the study population were reflective of those of the source population of dairy veterinarians thus minimizing non-response bias. The questionnaire design attempted to limit the potential for bias in responding by relying heavily on 5-point Likert scale questions, some with frequency scales (Never — Always), which appear to have minimized this potential bias. The response distributions did not indicate the presence of significant positive skewing, central tendency, acquiescence bias, or faking good (16).

The definition of a valid VCPR in the regulations under the *Veterinarians Act of Ontario* includes the elements that a veterinarian has "sufficient knowledge" through "timely visits to the premises," that he/she believes that "the drug is prophylactically or therapeutically indicated for the animal," and that the producer "has indicated a willingness to accept the advice" (17). Our questions regarding dispensing policies focused on 2 antimicrobials; penicillin G (non-prescription) and ceftiofur (prescription) (18). We found that most of the responders applied the concept of a valid VCPR in dispensed antimicrobials. Our survey instrument did not establish the extent to which responses reflected clinic level policy or individual case-by-case dispensing behavior. Responses to this question did establish that farm visit frequency and prescription status of an antimicrobial were used by veterinarians as discriminating factors in determining the limitations on OTC dispensing. There was evidence of a policy shift to less OTC dispensing with a greater requirement for consultation as the VCPR became more tenuous. Multivariable models indicated that practice and individual demographic factors, generation of veterinarian and his/her time spent on dairy practice, may affect dispensing policy. Practitioners with < 26% of their time in dairy herds may be applying a more cautious OTC dispensing policy, preferring to dispense antimicrobials while on-farm. Less specialized practices may not be destinations for producers to pick up drugs. Younger dairy veterinarians may feel some level of intimidation by demanding producers as they try to establish themselves in their practices and wanting to avoid confrontation over access to drugs.

Veterinarians should demonstrate an attitude of antimicrobial stewardship in their dispensing policies, given their role as a trusted advisor to producers. A survey of Ontario producers found that 99% of respondents ranked their herd veterinarian as a primary source of advice on antimicrobial use and 96% identified their veterinarian as a primary retail source of antimicrobial products for their herd (14). Another study noted that 94% of producer respondents relied on veterinarians most in dealing with health management issues (19). A study involving South Carolina producers suggested that herd veterinarians are viewed as credible sources of information about antimicrobial use and that a functional VCPR can influence attitudes of farm workers about the potential occupational hazards associated with antimicrobial resistance on the farm (20).

Implicit in the question about considerations in antimicrobial selections was that there was a presumptive diagnosis of a bacterial infection, given the empirical knowledge of the clinician, and the need for antimicrobial treatment was justified; this question was not intended to solicit pharmacodynamic/pharmacokinetic considerations in drug selection (21) beyond efficacy of an antimicrobial for the given condition. Respondents indicated that the potential for resistance development and veterinarian's profit were rarely considered in selecting an antimicrobial, while efficacy, labeled for use in lactating dairy cow, and milk withdrawal time were the primary considerations, all of which are among the key elements of prudent antimicrobial use (6,7).

In this study, antimicrobial use protocol provision by veterinarians (28%) was similar to data from producer respondents in Pennsylvania (21%) (22), Washington State (27%) (19), and South Carolina (32%) (20), who indicated having written treatment plans in place (pre-printed or written at the time of visit *versus* verbal instructions only). A Wisconsin study showed that the use of written treatment protocols increased with herd size, likely driven by a need for standardized procedures as the number of farm personnel increased, and that 60% were written by a veterinarian (23). Interviews with South Carolina producers revealed that while protocols were not available as formal written documents, daily herd management still followed standard operating procedures developed through personal experience (20). Our study also revealed that the majority of veterinarians provided written instructions when dispensing antimicrobials OTC and on-farm. However, record quality in terms of case specific instructions was generally low, irrespective of dispensing location, which could result in poor producer compliance and/or improper antimicrobial use. While our findings indicated that respondents may have deferred antimicrobial use instruction to the product label, the *Ontario Veterinarians Act* requires veterinarians to provide complete dispensing instructions to producers; some respondents may have assumed that the manufacturer's label information meets the requirements for providing directions on use of the product. At the time of our survey, the Canadian dairy industry was developing, but had yet to implement, the Canadian Quality Milk (CQM) program (11), which included a requirement that producers maintain treatment protocols and records under the guidance of their herd veterinarian (24).

Most respondents agreed that antimicrobial use in the dairy industry could contribute to decreased efficacy in dairy cattle.

These results are similar to those from a study reporting that 74% of producers agreed that "antibiotics become less effective the more they are used" and a majority of producers (59%) agreed that antibiotic use in food animals could affect human health, but only 34% felt that a cow with an antimicrobial resistant infection in the herd would pose a threat to farm workers (19). Interviews with South Carolina dairy producers revealed that 86% were not concerned about the potential for farm staff to carry antimicrobial resistant organisms in relation to the overuse of antimicrobials on the farm (20). Most respondents to our survey did not believe that antimicrobial use in dairy cattle had a public health impact. Furthermore, in selecting an antimicrobial, most of the respondents were not influenced by the potential for resistance development. However, 59% of Washington State dairy producers agreed that antibiotic use in food-producing animals could affect human health (19). Those in animal agriculture who disagree with this premise contend that the greatest determinant of antimicrobial resistance in humans is overuse/misuse by physicians. One assessment of physician prescribing behavior found that 61% of prescriptions met with guideline recommendations, 10% were for the use of newer important narrow spectrum antimicrobials, and in 20% of cases antibiotics were not indicated (25). Educational interventions aimed at curbing excessive or inappropriate prescriptions often focused on health economic outcomes, have met with varied success, and generally the net result has been modified prescription profiles of subject physicians (26–29). Calls for restricted use of antimicrobials in agriculture (30–32) and the need for veterinary leadership and education in developing strategies for the preservation of antimicrobials (10) have motivated several organizations to create prudent use guidelines (6,7), but there remains little in the way of sustained veterinary and producer education concerning antimicrobial use and resistance in a public health context. The Canadian Veterinary Medical Association has published species-specific prudent use guidelines, which ranked antimicrobial selection by their category of importance in human medicine, for various bacterial diseases. There is a need for additional research to better describe the potential public health impact of antimicrobial use on dairy farms.

In the years since this study was conducted there have been several initiatives [CgFARAD, CQM, Ontario Medical Association (OMA) policy paper] that may have impacted current veterinary dispensing practices and attitudes. CgFARAD, an ongoing service that was active at the time of this study, provides information to veterinarians pertaining to the extra-label use of drugs (ELDU) and the associated risks of violative residues (33). This program has provided limited advice on the potential for antimicrobial resistance development/dissemination, thus it is less likely to have had a significant impact on the dispensing of antimicrobials on dairy farms. On the other hand, the CQM program, an on-farm food safety/quality assurance program, requires producers to maintain drug inventory lists, log animal treatments, obtain veterinary prescriptions for ELDU and treatment protocols, and in turn increase awareness of the veterinarian's role as a key advisor on drug use, including antimicrobials (34).

The influence of prudent use guidelines, media, and veterinary and industry literature may have modified dispensing practices and antimicrobial use. Additionally, other initiatives have resulted in a call to action by commodity and veterinary organizations, and government agencies. New federal legislation on antimicrobial dispensing has been proposed (35). A recent policy paper published by the OMA has identified food-animal agriculture as major users of antimicrobials and has made several recommendations regarding how antimicrobials should be dispensed in this sector (36). Assuming there has been a shift in attitudes by policy makers toward greater antimicrobial stewardship, it is speculated that there will be a trickle down effect to end users, veterinarians and producers. A follow-up study is warranted to collect current data in Ontario dairy herds in order to assess if and how dispensing practices have changed since 2001.

In general, respondents indicated the requirement for some form of consultation prior to dispensing penicillin or ceftiofur increased as the VCPR became more tenuous, and a shift towards more restrictive dispensing policies was greater for ceftiofur than for penicillin. Most respondents frequently provided written instruction when dispensing an antimicrobial and just over half frequently added this information to the main clinic medical record for that farm. None of the respondents provided complete OTC dispensing records, whereas 27% provided complete records when dispensing on-farm. Potential antimicrobial resistance development was not a primary consideration in the selection of an antimicrobial but there was general agreement among respondent veterinarians that antimicrobial use in the dairy industry was a contributor to antimicrobial resistance in cattle. The majority disagreed that it could have a negative impact on human medicine. As trusted advisors to producers, veterinarians play a key role in antimicrobial stewardship in directing the appropriate use of these important drugs.

Acknowledgments

This project was supported by the Ontario Ministry of Agriculture and Food, Food Safety Program and by the Laboratory for Foodborne Zoonosis, Public Health Agency of Canada. We are grateful to the Ontario dairy veterinarians who participated in this research project by responding to the questionnaires. We thank Andrea Rowe, Heather Aitken, Mary Lichti, Alison Mather, and Betsy Varughese for their help with data management. We also acknowledge and are grateful for the statistical support provided by William Sears. CVJ

References

1. World Health Organization. The Medical Impact of Antimicrobial Use in Food Animals, Report of a WHO Meeting. Berlin, Germany. WHO/EMC/ZOO/97.4 [Web Page]. 1997; Available from: http://whqlibdoc.who.int/hq/1997/WHO_EMC_ZOO_97.4.pdf Last accessed April 27, 2015.
2. World Health Organization. WHO global principles for the containment of antimicrobial resistance in animals intended for food. WHO/CDS/CSR/APH/2000.4 [Web Page]. 2000; Available from: http://www.who.int/salmsurv/links/en/GSSGlobalPrinciples2000.pdf Last accessed April 27, 2015.
3. Avorn JL, Barrett JF, Davey PG, McEwen SA, O'Brien TF, Levy SB. Antibiotic resistance: Synthesis of recommendations by expert policy groups. WHO/CDS/CSR/DRS/2001.10 [Web Page]. 2001; Available from: http://whqlibdoc.who.int/hq/2001/WHO_CDS_CSR_DRS_2001.10.pdf Last accessed April 27, 2015.

4. American Veterinary Medical Association. AABP/AVMA Judicious Therapeutic Use of Antimicrobials in Cattle [Web Page]. 2014; Available from: https://www.avma.org/KB/Policies/Pages/AABP-Prudent-Drug-Usage-Guidelines-for-Cattle.aspx?PF=1 Last accessed April 27, 2015.
5. Canadian Veterinary Medical Association. CVMA guidelines on the prudent use of antimicrobial drugs in cattle [Web Page]. 2001; Available from: http://canadianveterinarians.net/ShowText.aspx?ResourceID=86 Last accessed April 27, 2015.
6. Veterinary Drugs Directorate, HCGoC. Release of the Final Report of the Advisory Committee on Animal Uses of Antimicrobials and Impact on Resistance and Human Health [Web Page]. 2002; Available from: http://www.hc-sc.gc.ca/dhp-mps/pubs/vet/amr-ram_background-documentation-eng.php Last accessed April 27, 2015.
7. FAAIR Scientific Advisory Panel. Policy recommendations. Clin Infect Dis 2002;34 Suppl 3:S76–S77.
8. Morley PS, Apley MD, Besser TE, et al. Antimicrobial drug use in veterinary medicine. J Vet Intern Med 2005;19:617–629.
9. Meek AH, Martin SW, Stone JB, McMillan I, Britney JB, Grieve DG. The relationship among current management systems, production, disease and drug usage on Ontario dairy farms. Can J Vet Res 1986;50: 7–14.
10. Hady PJ, Lloyd JW, Kaneene JB. Antibacterial use in lactating dairy cattle. J Am Vet Med Assoc 1993;203:210–220.
11. Dairy Farmers of Canada. Canadian Quality Milk — The Program [Web Page]. Available from: http://www.dairygoodness.ca/en/trade-and-industry/organization/programs/canadian-quality-milk/program.htm Last accessed April 27, 2015.
12. Livestock Medicines Education Committee, UoGRC. Livestock Medicines Education Program [Web Page]. Available from: http://www.ontariolivestockmed.com/ Last accessed April 27, 2015.
13. Veterinary Drugs Directorate, HCGoC. Categorization of Antimicrobial Drugs Based on Importance in Human Medicine [Web Page]. 2009; Available from: http://www.hc-sc.gc.ca/dhp-mps/vet/antimicrob/amr_ram_hum-med-rev-eng.php Last accessed April 27, 2015.
14. Leger DF. Antimicrobial use by free-stall dairy producers and veterinarians in Ontario [MSc dissertation]. Guelph, Ontario: University of Guelph, 2009.
15. Dairy Farmers of Ontario. Dairy Statistical Handbook 2004–2005 [Web Page]. 2007; Available from: http://www.milk.org/Corporate/pdf/Publications-DairyStatsHandbook.pdf Last accessed April 27, 2015.
16. Streiner DL, Norman GR. Biases in responding. In: Streiner DL, Norman GR. Health measurement scales — A practical guide to their development and use. 2nd ed. New York, New York: Oxford University Press, 1995:69–82.
17. Government of Ontario. Veterinary Act, Regulation 1093. R.R.O. 1990, Reg. 1093, s. 33 (1); O. Reg. 431/00, s. 7. R.R.O. 1990, Reg. 1093, s. 33 (1); O. Reg. 431/00, s. 7. 1990.
18. Compendium of Veterinary Products. CVP. Hensall, Ontario: North American Compendiums Ltd., 2001.
19. Raymond MJ, Wohrle RD, Call DR. Assessment and promotion of judicious antibiotic use on dairy farms in Washington State. J Dairy Sci 2006;89:3228–3240.
20. Friedman DB, Kanwat CP, Headrick ML, Patterson NJ, Neely JC, Smith LU. Importance of prudent antibiotic use on dairy farms in South Carolina: A pilot project on farmers' knowledge, attitudes and practices. Zoonoses Public Health 2007;54:366–375.
21. Erskine RJ, Wagner S, DeGraves FJ. Mastitis therapy and pharmacology. Vet Clin North Am Food Anim Pract 2003;19:109–138.
22. Sawant AA, Sordillo LM, Jayarao BM. A survey on antibiotic usage in dairy herds in Pennsylvania. J Dairy Sci 2005;88:2991–2999.
23. Hoe FG, Ruegg PL. Opinions and practices of Wisconsin dairy producers about biosecurity and animal well-being. J Dairy Sci 2006;89: 2297–2308.
24. Dairy Farmers of Canada. Canadian Quality Milk — Reference Manual, On-Farm Food Safety Program [Web Page]. 2003; Available from: http://www.dairyinfo.gc.ca/pdf/referencemanual.pdf Last accessed April 27, 2015.
25. Jelinski S, Parfrey P, Hutchinson J. Antibiotic utilisation in community practices: Guideline concurrence and prescription necessity. Pharmacoepidemiol Drug Saf 2005;14:319–326.
26. De Santis G, Harvey KJ, Howard D, Mashford ML, Moulds RF. Improving the quality of antibiotic prescription patterns in general practice. The role of educational intervention. Med J Aust 1994;160: 502–505.
27. Hux JE, Melady MP, DeBoer D. Confidential prescriber feedback and education to improve antibiotic use in primary care: A controlled trial. CMAJ 1999;161:388–392.
28. Stewart J, Pilla J, Dunn L. Pilot study for appropriate anti-infective community therapy. Effect of a guideline-based strategy to optimize use of antibiotics. Can Fam Physician 2000;46:851–859.
29. McIsaac WJ, Goel V, To T, Permaul JA, Low DE. Effect on antibiotic prescribing of repeated clinical prompts to use a sore throat score: Lessons from a failed community intervention study. J Fam Pract 2002; 51:339–344.
30. van den Bogaard AE, Stobberingh EE. Epidemiology of resistance to antibiotics. Links between animals and humans. Int J Antimicrob Agents 2000;14:327–335.
31. Lipsitch M, Singer RS, Levin BR. Antibiotics in agriculture: When is it time to close the barn door? Proc Natl Acad Sci USA 2002;99: 5752–5754.
32. Singer RS, Finch R, Wegener HC, Bywater R, Walters J, Lipsitch M. Antibiotic resistance — The interplay between antibiotic use in animals and human beings. Lancet Infect Dis 2003;3:47–51.
33. CgFARAD. [Homepage on the Internet] c2012. Available from: http://www.cgfarad.usask.ca/home.html Last accessed April 27, 2015.
34. Canadian Quality Milk (CWM) website [homepage on the Internet] c2014 Dairy Farmers of Ontario. Available from: https://www.milk.org/Corporate/Content.aspx?id=361 Last accessed April 27, 2015.
35. HC-VDD legislative changes.
36. Ontario Medical Association Policy Paper. When antibiotics stop working. Ont Med Rev 2013: March:27–43. Available from: https://www.oma.org/Resources/Documents/Antibiotics03192013.pdf Last accessed April 27, 2015.