Article

Producer attitudes regarding antimicrobial use and resistance in Canadian cow-calf herds

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Abstract

Objective

To describe producer attitudes toward antimicrobial use (AMU) and antimicrobial resistance (AMR), identify factors associated with attitudes, and inform stewardship initiatives.

Animal

Beef cattle, cow-calf.

Procedure

Cow-calf producers from the Canadian Cow-Calf Surveillance Network (C3SN) completed a survey (n = 146) on producers' attitudes toward AMU, AMR, and impacts of recent regulatory changes requiring a prescription for the purchase of medically important antimicrobials (MIA).

Results

Most producers (78%, 114/146) reported being aware of initiatives to improve antimicrobial stewardship within the beef industry and 67% (97/146) indicated that AMR was a highly important issue to the industry and producers personally. Almost half of producers reported concerns that AMR development has impacted AMU decisions on their operations. Overall, veterinarians were producers' primary source of information regarding AMU, including treatment protocols, stewardship programs, and regulatory changes. Following introduction of the 2018 prescription-only regulations, 95% (138/146) of producers reported no change in AMU on their operations. Similarly, 77% (112/146) of producers reported no change in antimicrobial product access, whereas 63% (91/146) reported no change in cost.

Conclusion

Most producers reported little change in access to antimicrobials and in AMU following the introduction of regulations requiring a prescription for MIA.

Clinical relevance

Producers rely on veterinarians as their primary source of information regarding antimicrobial regulations and AMU. It is therefore important for veterinarians to understand their role as educators for beef cow-calf producers. Ultimately, veterinarians and producers need to work together to ensure that the health and welfare of animals are protected while using antimicrobials in a responsible manner.

Résumé

Attitudes des producteurs à l'égard de l'utilisation des antimicrobiens et de la résistance dans les troupeaux vache-veau canadiens

Objectif

Décrire les attitudes des producteurs à l'égard de l'utilisation des antimicrobiens (AMU) et de la résistance aux antimicrobiens (RAM), identifier les facteurs associés à ces attitudes et les informations sur les initiatives de gouvernance.

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Animal
Bovins de boucherie, vache-veau.

Procédure
Les producteurs naisseurs du Réseau canadien de surveillance vache-veau (C3SN) ont répondu à une enquête (*n* = 146) sur les attitudes des producteurs à l'égard de l'AMU, de la RAM et des impacts des récents changements réglementaires exigeant une ordonnance pour l'achat d'antimicrobiens médicalement importants (MIA).

Résultats
La plupart des producteurs (78 %, 114/146) ont déclaré être au courant des initiatives visant à améliorer la gouvernance des antimicrobiens au sein de l'industrie du bœuf et 67 % (97/146) ont indiqué que la RAM était un problème très important pour l'industrie et les producteurs personnellement. Près de la moitié des producteurs ont fait part de leurs inquiétudes quant au fait que le développement de la RAM ait un impact sur les décisions d'AMU sur leurs opérations. Dans l'ensemble, les médecins vétérinaires étaient la principale source d'information des producteurs concernant l'AMU, y compris les protocoles de traitement, les programmes de gouvernance et les changements réglementaires. À la suite de l'introduction de la réglementation sur prescription uniquement en 2018, 95 % (138/146) des producteurs n'ont signalé aucun changement dans l'AMU de leurs opérations. De même, 77 % (112/146) des producteurs n'ont signalé aucun changement dans l'accès aux produits antimicrobiens, tandis que 63 % (91/146) n'ont signalé aucun changement dans le coût.

Conclusion
La plupart des producteurs ont signalé peu de changements dans l'accès aux antimicrobiens et dans l'AMU par suite de l'introduction de réglementations exigeant une prescription pour le MIA.

Pertinence clinique
Les producteurs comptent sur les médecins vétérinaires comme principale source d'information concernant la réglementation antimicrobienne et l'AMU. Il est donc important que les médecins vétérinaires comprennent leur rôle d'éducateurs auprès des producteurs de vaches-veaux de boucherie. En fin de compte, les médecins vétérinaires et les producteurs doivent travailler ensemble pour garantir la protection de la santé et du bien-être des animaux tout en utilisant les antimicrobiens de manière responsable.

(Traduit par Dr Serge Messier)

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Introduction

With growing international attention on antimicrobial use (AMU) and risks of antimicrobial resistance (AMR), the Government of Canada implemented regulations addressing the sale of veterinary antimicrobials. After 2004, all new antimicrobial products entering the Canadian market were categorized as medically important antimicrobials (MIA), requiring a veterinarian's prescription (1). In December 2018, the regulation of veterinary antimicrobials was enhanced, placing all MIA licenced for use in Canada under prescription-only status (1).

As a consequence of these new regulations, antimicrobials previously available through retail outlets, such as tetracyclines and sulphonamides, required a veterinary prescription. Based on a 2014 survey, tetracyclines and sulphonamides were used at least once in > 80% of western Canadian cow-calf operations (2,3), indicating the importance of these antimicrobials in cow-calf herd management. The potential impact of the new regulations has not yet been investigated across all sectors of the Canadian livestock industry.

The Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) is the national surveillance network that collects, analyzes, and communicates trends in AMU and AMR for select bacteria from humans, animals, and retail meat across Canada. The program includes information on the type and number of antimicrobials sold, as well as the volume of antimicrobials distributed for sale by livestock species, and major reasons for use (4). Although cow-calf operations are a critical component in the food supply chain, they are not included in the current on-farm national surveillance initiatives. They are also the most common livestock operation in Canada, with ~54 000 farms nationally, of which roughly 40 000 are located in western Canada (5) The cow-calf industry directly contributes to the food chain through the sale of cull cows and bulls, as well as by supplying cattle to backgrounding operations and feedlots. Therefore, obtaining information on the use of antimicrobials in this population is very relevant to understanding AMU in the Canadian livestock industry.

An attitude, defined as "a relatively enduring and general evaluation," can have a substantial effect on behaviors (6). Whereas the relationship between attitudes and behaviors is important, it very likely is non-linear (7). As attitudes move from extremely negative to extremely positive, a conceptual curve describing corresponding changes in behavior also changes. First, from relatively flat (*e.g.,* as attitudes move from extremely negative to moderately negative) to relatively steep, as attitudes cross midpoint from negative to positive; and then finally to relatively flat again (*e.g.,* as attitudes shift from moderately positive to extremely positive) (7). Understanding factors associated with differences in producer attitudes toward antimicrobial use, resistance, and stewardship could be important for understanding and informing AMU behaviors and targeting educational campaigns.

Table 1. Summary of responses for the top 3 factors considered by beef producers when determining if treatment is required, choosing antimicrobials, and determining dosage.

Factors considered	Number (%) of herds (n = 146) for each category		
	Determining if treatment is required[a]	Choosing an antimicrobial[a]	Determining antimicrobial dosage[a]
Verbal veterinary advice for specific animal	**104 (71%)**	**104 (71%)**	**96 (66%)**
Severity of disease	**89 (61%)**	**70 (48%)**	—
Concern about animals' well-being	**80 (55%)**	**47 (32%)**	—
Verbal advice from veterinarian not specific to animal	**34 (23%)**	**40 (27%)**	25 (17%)
Cost of disease in herd	**29 (20%)**	13 (8.9%)	—
Written veterinary protocol for herd	24 (16%)	30 (21%)	**27 (19%)**
Withdrawal time	17 (12%)	10 (6.8%)	1 (0.7%)
Drug cost *versus* chance of success	16 (11%)	24 (16%)	—
Multiple doses required	14 (9.6%)	**41 (28%)**	—
Written veterinary recommendations for specific animal	9 (6.2%)	13 (8.9%)	12 (8.2%)
Route of administration	6 (4.1%)	14 (9.6%)	10 (6.8%)
Other	5 (3.4%)	8 (5.5%)	4 (2.7%)
Drug accessibility	4 (2.7%)	9 (6.2%)	—
Potential for ineffective treatment due to antimicrobial resistance	3 (2.1%)	2 (1.4%)	—
Advice from non-veterinary source (friend/neighbor)	—	9 (6.2%)	3 (2.1%)
Package instructions	—	—	**109 (75%)**
Visual estimate of animal weight	—	—	**99 (67%)**
Based on measured weight	—	—	**34 (23%)**
Use same dosage as previous treatment	—	—	7 (4.8%)
Drug cost	—	—	1 (0.7%)
Internet instructions	—	—	1 (0.7%)
Side effects/safety concerns	—	1 (0.7%)	—
Potential for antimicrobial resistance from this drug	—	1 (0.7%)	—
Mixing of drug required	—	0 (0%)	—
Refrigeration of drug required	—	0 (0%)	—
Total responses	434[b]	436[b]	429[b]

[a] The 5 most frequent responses are in bold font.
[b] Not all producers provided 3 responses.

Baseline data on AMU and some aspects of producer attitudes toward AMU from western Canadian cow-calf herds were collected in 2014 (2,3). Older information also described AMU practices within a small number of cow-calf herds in the eastern province of Ontario (3,8). Producer attitudes toward AMU have not been reported at a national level. Such an investigation would also provide an opportunity to assess producer perceptions of any effects on AMU of the regulatory changes in December 2018.

The primary objective of this study was to describe producer attitudes toward AMU and AMR, as well as to identify factors associated with AMU in Canadian cow-calf herds that could inform antimicrobial stewardship, defined as "ensuring that the beef industry uses the right antimicrobials in the right animals at the right dose at the right time." The second objective was to determine if there have been changes in producer use, access, or cost of antimicrobials following regulatory changes that were implemented in 2018.

Materials and methods

Survey design

A paper-based survey was developed based on an AMU survey administered to western Canadian producers in 2014 (2). Survey development and testing methods for the current survey were the same as those described for the 2014 investigation (2). In addition to the survey, producers were provided with an updated antimicrobial drug handbook (June 2019) to aid recall. The handbook included commercial and generic drug names with color photographs of antimicrobial products approved for use in Canada.

Survey content

The survey consisted of 2 sections. The first collected AMU information between July 1, 2019, and June 30, 2020, for nursing calves, weaned calves, breeding females, and bulls. Questions included whether antimicrobials were administered to specific production categories of cattle and for specific reasons. If AMU was reported, the next questions inquired which antimicrobial product was administered, the percentage of animals in the herd that received the product, the typical number of doses used for the treatment protocol, and dose per animal, as well as the route of administration. Data from this section of the survey will be reported elsewhere (9).

The second section of the survey focused on producer perceptions of AMU and decision-making strategies for AMU. The first set of questions asked producers if they perceived a decrease in antimicrobial effectiveness for common conditions (respiratory, gastrointestinal, lameness); and then, if the potential for reduced effectiveness and attendant impact of AMR in human medicine affected their decision-making process regarding AMU. Producers were also asked what they do when an antimicrobial treatment fails for each of 3 common conditions, and where they source information regarding antimicrobials.

Table 2. Beef producer opinions regarding changes in antimicrobial effectiveness for common diseases during the previous 5 y.

	Number (%) of herds (n = 146) for each category		
Opinion	Respiratory disease	Gastrointestinal disease	Lameness
Increased	14 (9.6%)	9 (6.0%)	7 (4.8%)
Stayed the same	**109 (75%)**	**90 (62%)**	**99 (68%)**
Decreased	10 (6.8%)	15 (10%)	28 (19%)
No opinion	13 (8.9%)	32 (22%)	12 (8.2%)

The most frequent response is in bold font.

Table 3. Top 3 responses by beef producers describing their next response following a failed first treatment for 3 common diseases.

	Number (%) of herds (n = 146) for each category		
Response	Respiratory disease	Gastrointestinal disease	Lameness
Consult a veterinarian	**108 (74%)**	**100 (68%)**	**71 (49%)**
Treat with a different antibiotic	**103 (71%)**	**67 (46%)**	**78 (53%)**
Treat with a different drug/product that is not an antibiotic	10 (6.8%)	52 (36%)	14 (10%)
Provide no further treatment	10 (6.8%)	7 (4.8%)	17 (12%)
Cull or euthanize the animal	10 (6.8%)	3 (2.1%)	18 (12%)
Other	10 (6.8%)	13 (8.9%)	33 (23%)
Total responses	251	242	231

The most frequent responses are in bold font.

In addition, questions about the reasons for deciding to treat an animal, and why producers choose specific antimicrobial products and dosages, were included.

Producers were also questioned regarding their AMU records, antimicrobial stewardship practices, and whether they thought antimicrobial stewardship, defined as "ensuring that the beef industry uses the right antimicrobials in the right animals at the right dose at the right time," was an important issue for the beef industry and human health. Finally, producers were asked about the 2018 Canadian regulations placing all MIA under prescription-only status and whether their AMU, access to antimicrobials, or cost of antimicrobials had changed as a result. Where these questions were not answered or not answered entirely, producers were contacted for follow-up.

Participant recruitment and survey distribution

In June 2020, hard-copy surveys were distributed *via* mail to 168 participants in the Canadian Cow-Calf Surveillance Network (C3SN), which was established in 2018 (10) and includes producers from all regions of Canada. Participating herds were recruited to the C3SN through consultation with veterinarians, advertisements with research agencies such as the Beef Cattle Research Council (BCRC), provincial beef organizations, word of mouth, and previous research networks.

Recruitment targeted herds that contained at least 40 breeding animals, had reported pregnancy checking, and had at least basic calving and production records. In addition, access to email was requested to allow for efficient communication (11). Network participants were provided with an honorarium for completion of the survey.

Data management and analyses

Using commercial software (Microsoft Access and Excel; Microsoft, Redmond, Washington, USA), data from the 2020 AMU survey were merged with data from the 2019 general herd management, breeding, and weaning survey, as well as from the 2020 calving survey. These surveys were based on previously described tools (12). Information on factors affecting AMU decisions, producer attitudes to AMU and AMR, and perceptions of the impact of prescription drug regulations was summarized.

Logistic regression was used to examine associations between herd and producer attributes and responses to questions regarding the importance of AMR to the beef industry, as well as changes in use, access, and cost of antimicrobials since the imposition of the new regulations. Specific herd and producer attributes considered included location of the herd (western *versus* eastern Canada), herd size, whether a producer backgrounded calves, age of the primary decision-maker, and type of herd. Herds were identified as having either some reported seedstock or no seedstock on the operation. The number of animals purchased by each herd during the year were categorized as above or below the median for all herds. Potential risk factors were selected based on previous publications (2,3) and expert opinion obtained through interviews with C3SN network members and associated veterinary faculty.

Exploratory analyses were completed for outcomes of interest using a commercial software program (STATA 16; StataCorp, College Station, Texas, USA), by first screening all unconditional associations to identify potential risk factors. Variables with a P-value < 0.20 were considered for inclusion in final models. Multivariable models were only created if > 1 variable met the screening criteria. However, this was not the case for any of the outcomes examined in this analysis. Unconditional estimates were reported as odds ratios (OR) with 95% confidence intervals (95% CI).

Results

Description of participating herds

In total, 146 surveys were returned, for an overall response rate of 87%. When the response rate for specific questions was different, the appropriate denominator was reported. Approximately 2/3 (67%, 98/146) of respondents were in western Canada (British Columbia, Alberta, Saskatchewan, Manitoba) and 1/3 (33%, 48/146) were in eastern Canada and the Maritime provinces (Ontario, Quebec, New Brunswick, Nova Scotia). Of the 146 respondents, 52 had previously provided data for the Western Canadian Cow-Calf Surveillance Network (2,3,13).

The median numbers of cows and heifers calving per herd were 124 (range: 14 to 1044), and 18 (range: 0 to 210), respectively. The median number of cows calving per herd in the west was 131 (range: 23 to 1044) and the median number of heifers calving was 19 (range: 0 to 210). In the east, the median number

Table 4. Sources of information used by beef producers regarding antimicrobials and stewardship.

Source of information	Number (%) of herds (n = 146) for each category: Information on antimicrobials	Information on stewardship
Veterinarian	**144 (99%)**	**129 (88%)**
Friends and neighbors	**35 (24%)**	17 (12%)
Producer publications	**24 (16%)**	**57 (39%)**
Beef industry meetings/trade shows	**24 (16%)**	**54 (37%)**
Feed or drug company representative	**23 (16%)**	17 (12%)
Industry/drug company website	21 (14%)	13 (8.9%)
Nutritionists	9 (6.2%)	7 (4.8%)
Scientific journals	8 (5.5%)	7 (4.8%)
Social media/blogs	6 (4.1%)	15 (10%)
Government publications/websites	4 (2.7%)	**28 (16%)**
Other	7 (5.5%)	12 (8.2%)
Unaware of programs	—	**18 (12%)**

The most frequent responses are in bold font.

Table 5. Beef producer sources of information regarding prescription-only regulations imposed December 1, 2018.

Source of information	Number (%) of herds (n = 146) for each category: Information on antimicrobial regulations
Veterinarian	109 (75%)
Beef industry meetings/trade shows	30 (21%)
Producer publications	21 (14%)
Government publications/websites	13 (8.9%)
Feed/drug company representative	10 (6.8%)
Industry/drug company website	10 (6.8%)
Friends and neighbors	7 (4.8%)
Other	6 (4.1%)
Nutritionists	4 (2.7%)
Don't remember	4 (2.7%)
Unaware of changes	3 (2.1%)
Social media/blogs	3 (2.1%)
Scientific journals	2 (1.4%)
Webinars	2 (1.4%)

Producers selected were asked to select all applicable responses.

of cows calving per herd was 67 (range: 14 to 578) whereas the median number of heifers calving was 8 (range: 0 to 109). The median number of bulls per herd was 7 (range: 1 to 58). Most herds (62%, 90/146) did not report the sale of any seedstock from their operation.

Producer attitudes toward treatment

Producers were asked to select the top 3 factors that they consider when determining if a treatment is required, in choosing an antimicrobial, and in determining the dosage (Table 1). The most popular reason for determining when treatment was required was verbal advice from a veterinarian about a specific animal (71%) (Table 1). In addition, producers considered disease severity (61%) and animal well-being (55%) when determining whether treatment was required.

Similarly, the most popular reason for antimicrobial selection was based on veterinary advice (Table 1). Other factors influencing the choice of antimicrobial were disease severity (48%), animal well-being (32%), and number of doses required (28%).

Table 6. Beef producer-reported changes related to antimicrobial use in their herds since December 2018.

	Number (%) of herds (n = 146) for each category: Decreased	No change	Increased
Producers reporting changes to:			
Antimicrobial use (n = 145)	6 (4%)	138 (95%)	1 (1%)
Antimicrobial access (n = 145)	31 (21%)	112 (77%)	2 (2%)
Cost of antimicrobials (n = 145)	2 (2%)	91 (63%)	51 (35%)

The most common factor determining the antimicrobial dosage was referral to the package instructions (75%), followed by visual weight estimates (67%) and verbal advice from a veterinarian (66%).

Treatment of common diseases

Producers were presented with statements regarding AMU within the previous 5 y on their operation and were then asked whether they agreed, were neutral, disagreed, or had no opinion. The first question asked if AMR and potential loss of treatment effectiveness on their farms had limited their antimicrobial choices. Of the 146 respondents, 49% (71) agreed with the statement, 30% (44) were neutral, 14% (21) disagreed, and 7% (10) had no opinion.

Producers were then asked if AMU in cattle and its effect on AMR in human medicine limited their use of Category I antimicrobials deemed by Health Canada to be of very high importance to human health (14). Almost equal numbers of producers agreed (27%, 39/146), were neutral (24%, 35/146), disagreed (24%, 35/146), or reported no opinion (25%, 37/146).

All producers responded to the question regarding changes in their perception regarding the effectiveness of antimicrobials when treating common diseases (respiratory, gastrointestinal, and lameness) during the previous 5 y (Table 2). Most reported that antimicrobial effectiveness appeared unchanged. Producers were more likely to report a decrease in the effectiveness of antimicrobials when treating lameness than when treating gastrointestinal or respiratory disease.

Producers were asked to select up to 3 options regarding their next course of action following a failed first treatment with antimicrobials for each of 3 common conditions (respiratory, gastrointestinal, and lameness). When dealing with a failed first treatment for respiratory and gastrointestinal diseases, 74 and 68% of respondents, respectively, turned to their veterinarian for advice (Table 3). Treatment with a different antimicrobial was the most common response for a failed lameness treatment (53%), whereas treatment with another antimicrobial was the second-most common response for failed respiratory (71%) and gastrointestinal (46%) disease treatments.

After treatment failure, non-antibiotic products used for treatment of respiratory disease included non-steroidal anti-inflammatory drugs (NSAIDs) such as meloxicam (2.1%, 3/146), and steroidal medications such as dexamethasone (0.7%, 1/146). Combinations of oral electrolytes and NSAIDs (19%, 28/146) were the most commonly reported non-antibiotic products used to treat gastrointestinal diseases when an antimicrobial treatment

Table 7. Unconditional associations for beef producer attitudes toward antimicrobial use and antimicrobial resistance based on herd attributes in Canadian herds ($n = 146$).

Producer attitudes and risk factors of interest	Odds ratio	95% CI		*P*-value
		Lower	Upper	
Considered AMR to be at least moderately important to the industry (n = 143)				
Western Canada (n = 98):eastern Canada (n = 48)	1.37	0.22	8.53	0.73
Decision-maker < 30 y (n = 23)	0.74	0.08	6.93	0.79
Any seedstock (n = 56)	0.40	0.06	2.48	0.33
Purchased animals (n = 77)	0.27	0.03	2.46	0.25
Backgrounded calves (n = 93)	0.43	0.05	3.93	0.45
Treated > 5% of preweaned calves (n = 67)	0.55	0.09	3.42	0.53
Reported decreased access to antimicrobials since imposition of new regulations (n = 31)				
Western Canada (n = 98):eastern Canada (n = 48)	1.04	0.44	2.42	0.93
Herd size > 300 (n = 31)	0.86	0.32	2.34	0.77
Decision-maker < 30 y (n = 23)	1.04	0.35	3.06	0.95
Any seedstock (n = 56)	1.21	0.54	2.71	0.64
Purchased animals (n = 77)	0.94	0.43	2.09	0.89
Backgrounded calves (n = 93)	1.05	0.46	2.39	0.92
Treated > 5% of preweaned calves (n = 67)	0.69	0.31	1.55	0.37
Reported increased cost of antimicrobials since imposition of new regulations (n = 51)				
Western Canada (n = 98):eastern Canada (n = 48)	1.27	0.61	2.66	0.51
Herd size > 300 (n = 31)	1.46	0.65	3.30	0.36
Decision-maker < 30 y (n = 23)	0.61	0.22	1.66	0.34
Any seedstock (n = 56)	1.75	0.87	3.51	0.12
Purchased animals (n = 77)	1.29	0.65	2.56	0.47
Backgrounded calves (n = 93)	0.83	0.41	1.67	0.59
Treated > 5% of preweaned calves (n = 67)	2.54	1.26	5.11	0.01
AMR and potential loss of treatment effectiveness limited choice of AMU in past 5 y (n = 71)				
Western Canada (n = 98):eastern Canada (n = 48)	1.27	0.46	3.50	0.65
Herd size > 300 (n = 31)	0.58	0.16	2.10	0.41
Decision-maker < 30 y (n = 23)	2.54	0.87	7.45	0.09
Any seedstock (n = 56)	0.60	0.22	1.65	0.32
Purchased animals (n = 77)	0.63	0.25	1.60	0.33
Backgrounded calves (n = 93)	1.16	0.44	2.09	0.76
Treated > 5% of preweaned calves (n = 67)	1.36	0.54	3.42	0.52
Potential impact of AMU in cattle on AMR in humans limited Category I use (n = 39)				
Western Canada (n = 98):eastern Canada (n = 48)	0.92	0.41	2.05	0.84
Herd size > 300 (n = 31)	0.91	0.35	2.33	0.84
Decision-maker < 30 y (n = 23)	1.48	0.56	3.97	0.43
Any seedstock (n = 56)	0.93	0.43	2.05	0.87
Purchased animals (n = 77)	0.93	0.44	2.00	0.86
Backgrounded calves (n = 93)	1.12	0.51	2.49	0.78
Treated > 5% of preweaned calves (n = 67)	0.45	0.20	1.01	0.05
Potential impact of AMU in cattle on AMR in humans did not limit Category I use (n = 35)				
Western Canada (n = 98):eastern Canada (n = 48)	0.93	0.38	1.80	0.64
Herd size > 300 (n = 31)	2.47	1.07	5.71	0.03
Decision-maker < 30 y (n = 23)	0.96	0.35	2.65	0.94
Any seedstock (n = 56)	1.56	0.74	3.27	0.24
Purchased animals (n = 77)	1.06	0.51	2.22	0.87
Backgrounded calves (n = 93)	1.19	0.55	2.59	0.65
Treated > 5% of preweaned calves (n = 67)	1.17	0.56	2.43	0.68
Decrease in effectiveness of antimicrobials for treating respiratory disease, gastrointestinal disease, or lameness (n = 43)				
Western Canada (n = 98):eastern Canada (n = 48)	0.66	0.31	1.38	0.27
Herd size > 300 (n = 31)	0.64	0.25	1.62	0.35
Decision-maker < 30 y (n = 23)	1.68	0.67	4.24	0.27
Any seedstock (n = 56)	1.23	0.60	2.55	0.57
Purchased animals (n = 77)	1.04	0.51	2.13	0.91
Backgrounded calves (n = 93)	0.82	0.39	1.71	0.60
Treated > 5% of preweaned calves (n = 67)	1.18	0.58	2.41	0.64
Treat with a different antimicrobial when a treatment fails (n = 116)				
Western Canada (n = 98):eastern Canada (n = 48)	1.77	0.78	4.03	0.17
Herd size > 300 (n = 31)	2.86	0.81	10.20	0.10
Decision-maker < 30 y (n = 23)	1.27	0.40	4.07	0.68
Any seedstock (n = 56)	1.59	0.67	3.77	0.29
Purchased animals (n = 77)	1.35	0.61	3.04	0.46
Backgrounded calves (n = 93)	1.45	0.64	3.29	0.37
Treated > 5% of preweaned calves (n = 67)	1.14	0.51	2.56	0.75

Table 7. Unconditional associations for beef producer attitudes toward antimicrobial use and antimicrobial resistance based on herd attributes in Canadian herds ($n = 146$) *(continued)*.

Producer attitudes and risk factors of interest	Odds ratio	95% CI		*P*-value
		Lower	Upper	
Consult a veterinarian when a treatment fails (n = 124)				
Western Canada (n = 98):eastern Canada (n = 48)	2.31	0.73	7.29	0.15
Herd size > 300 (n = 31)	1.19	0.40	3.55	0.76
Decision-maker < 30 y (n = 23)	1.31	0.40	4.33	0.66
Any seedstock (n = 56)	1.24	0.49	3.18	0.65
Purchased animals (n = 77)	1.54	0.60	4.00	0.37
Backgrounded calves (n = 93)	0.91	0.35	2.37	0.85
Treated > 5% of preweaned calves (n = 67)	1.08	0.43	2.74	0.86

AMR — Antimicrobial resistance; AMU — Antimicrobial use; CI — Confidence interval.

failed. Non-antibiotic treatments for animals experiencing failed lameness treatments included NSAIDs (2.1%, 3/146), examinations and foot trims (9.6%, 14/146), amputations (1.4%, 2/146), and footbaths (1.4%, 2/146). In addition, comments described the use of laboratory tests for gastrointestinal disease, potentially fecal culture, to increase treatment effectiveness.

Producer attitudes toward and sources of information about antimicrobial use and antimicrobial resistance

Producers recognized the importance of AMR within the beef industry and in human medicine. Producers also acknowledged that antimicrobial stewardship programs are important to control development of AMR and that they have an important role. Of the 142 producers who responded, 97 (67%) indicated the issue of AMR was of high importance to both the industry and to them personally, and 44 (30%) indicated the issue was moderately important. Only a single producer suggested that the issue was not important.

Producers were given a list of common sources of information regarding AMU within the beef industry and asked to select all sources of information they used when seeking knowledge, advice, or instruction. This generated 305 responses from 146 respondents (Table 4). Veterinarians (99%) were the primary source selected by producers for information regarding AMU (Table 4). The next most popular source of information was friends and neighbors (24%). Producer publications, industry meetings, and feed/drug company representatives were tied for 3rd place. Very few producers sought information regarding antimicrobials *via* primary research or government publications.

Most producers (78%, 114/146) reported being aware of initiatives to increase antimicrobial stewardship within the beef industry. Communication with a veterinarian was the most common resource reported regarding stewardship initiatives; this was followed by producer publications, beef industry meetings, and trade shows (Table 4). Other sources of information on initiatives included government publications and websites, as well as the Canadian Roundtable for Sustainable Beef (CRSB), and producer programs such as Verified Beef Production Plus (VBP+).

Most producers were aware of the requirement for a prescription to purchase antimicrobial products after introduction of new regulations in December 2018, with only 2% of responding producers reporting that they were unaware of this (Table 5). The most commonly reported sources of information regarding the new regulations were veterinarians (75%), beef industry meetings and trade shows (21%), and producer publications (14%). Government publications, feed and pharmaceutical representatives, and websites were less commonly reported. Other sources included the CRSB and VBP+.

Following introduction of the new regulations in 2018, most producers (95%) reported no change in AMU on their operations (increased or decreased use) (Table 6). Similarly, most producers reported no change in antimicrobial product access (77%) or cost (63%). However, 1 in 5 producers reported decreased access to antimicrobials, and 1 in 3 reported increased cost. Only 2 producers reported increased access and decreased cost (Table 6).

Factors associated with attitudes to antimicrobial use, antimicrobial resistance, and regulation changes

Based on the unconditional analysis (Table 7), herd owners with > 300 breeding animals were 2.5 times more likely than those with smaller herds to report that AMR in human medicine did not limit use of Category I antimicrobials on their operation in the previous 5 y. Herd owners who reported treating > 5% of calves for any reason were nearly twice as likely to disagree with the statement "the potential impact of AMU in cattle on AMR in humans limited the use of Category I antimicrobials." Herd owners who reported treating > 5% of calves for any reason were also 2.5 times more likely to report an increase in the cost of antimicrobials since 2018 compared to those with herds where < 5% of calves were treated for any reason.

Discussion

To the authors' knowledge, this study includes the first survey of cow-calf producer attitudes toward AMU and AMR since Canadian antimicrobial regulatory changes were made in December of 2018. Before this survey, there was limited literature in North America regarding cow-calf producer attitudes toward AMU and AMR. This gap, together with the importance of understanding similarities and differences between Canadian and American producers, creates an interesting opportunity to discuss the current dataset in comparison both to previous Canadian and previous American data. Changes in regulations have been occurring in both the United States and Canada for the past decade. It is important to consider these changes and producer attitudes in combination because of the close relationship between these 2 beef systems.

Since December 2018, Canada requires a veterinary prescription for all Category III or higher antimicrobials used in animals (14), whereas, as of the first quarter of 2023, the USA allows over-the-counter (OTC) sales of some antimicrobials. The USA has, however, had at least 3 major regulatory changes in the last 10 y. First, in 2012, the Food and Drug Administration (FDA) published Guidance 209, which promoted judicious use of antimicrobials in food animals by limiting the use of MIA in feed or water for production or growth enhancement and by requiring veterinary oversight/consultation (15). Next, in 2013, the FDA published Guidance 213 that made recommendations for pharmaceutical companies to gradually phase out indications for use of antimicrobials for improvement in weight gain and/or feed efficiency (15). In 2015, the Veterinary Feed Directive (VFD) final rule came into effect; this continued to outlaw extra-label drug use (ELDU) in feed while requiring veterinary oversight for all VFDs in the context of a veterinary client patient relationship (VCPR). However, it also specifically defined the key elements used to define a VCPR (16). Most recently, in 2021, the FDA published Guidance 263, which took effect June 11, 2023 and requires drug manufacturers to voluntarily bring existing OTC antimicrobials and any new MIA under veterinary oversight, requiring a prescription for purchase and restricting them to therapeutic use (17). Although, since 2018, Canada has required a prescription for MIA and officially ended any label claims for growth promotion on MIA, Canadian regulations do allow for ELDU of antimicrobials in the feed (18).

Given recent regulatory changes in the USA and Canada, it is not surprising that the producer attitudes between the 2 countries are similar. In a 2019 survey of Tennessee producers, 22 and 58% of producers were very or moderately concerned about AMR, respectively (19). Producers in the current survey were more likely to state that AMR was of high (67%) as compared to moderate (30%) importance to them. However, this indicated that most producers surveyed on both sides of the border were at least moderately concerned about AMR.

The impact of the 2018 regulatory change varied across the outcomes (AMU, antimicrobial access, and antimicrobial cost) investigated. However, despite an increased cost reported by 35% of respondents, most producers reported no change in AMU, access, or cost. In addition to inflation, the increased cost of antimicrobials could reflect reduced price competition or different types of antimicrobials available for purchase after lay outlets were no longer potential vendors. Unfortunately, there are no previously collected data for comparison. It would be interesting to know whether American producers have experienced any changes in AMU, access, or cost due to the changes in regulations they have faced.

Although there is little previous information about producer attitudes toward the importance of AMR, relatively more studies have reported attitudes toward AMU in Canada and the USA. For example, attitudes reported in the current survey toward effectiveness of antimicrobials for common diseases of cows and calves indicated that most producers ($> 60\%$) believe there has been no loss in antimicrobial effectiveness. A 2019 American survey of producers reported similar attitudes among respondents, with 65% of producers either neutral or in disagreement with the statement that antimicrobials had reduced effectiveness (20). Whereas some respondents in the American study were not solely commercial cow-calf operators, it did appear that there is some consensus, and that most respondents using antimicrobials thought the products were effective.

In relation to previous Canadian studies, the current study shows that attitudes regarding antimicrobial effectiveness among Canadian producers are unchanged since 2014. In a 2014 survey of western Canadian beef cow-calf producers 12, 17, and 18% of producers reported reduced antimicrobial effectiveness for treatment of respiratory disease, gastrointestinal disease, and lameness, respectively (6). These findings are similar to those of the current study, where 6.8, 10, and 19% of producers reported reduced effectiveness for the same conditions, respectively. Overall, these data indicated consensus regarding antimicrobial effectiveness, across time and possibly across regions, as the current study surveyed producers across Canada and the 2014 study only surveyed western Canadian cow-calf producers.

Producer decisions regarding their next steps in the face of treatment failure varied across the 3 major disease syndromes studied (respiratory disease, gastrointestinal disease, or lameness). For respiratory and gastrointestinal diseases, consulting a veterinarian was the first option in the face of treatment failure, whereas trying a different antimicrobial was the first option in the case of treatment failure for lameness. These differences could reflect levels of confidence that a producer has in the diagnoses in these 3 respective areas, the perception of a veterinarian's expertise, or relative access to veterinary advice at the time of treatment decisions. For example, many cows with lameness are treated and re-treated, if necessary, on pasture, and are unlikely to be brought in for a veterinary examination. This situation presents an important opportunity for knowledge translation, as it is very likely that a nonresponsive lameness is not foot rot and is unlikely to respond to antimicrobials.

One limitation of survey-based studies is recall bias. Previous studies have reported variable quality of cow-calf herd records (8,21). The current survey was administered immediately following the target time frame of the study to mitigate recall bias. Most antimicrobial use occurs in the spring, during calving and before pasture turn out. The survey was distributed just following pasture turnout for most herds. Although a number of other tools and options were provided to aid recall for the AMU part of the survey, most of the questions reported here reflect the producers' current attitudes and opinions, limiting the importance of recall. However, questions on effectiveness were based on producer perception without the ability to cross-reference against questions capturing empirical data on treatment effectiveness.

Social pressures as a result of public scrutiny and stigmas around AMU and AMR in the beef industry could have affected producer responses due to social desirability bias and a fear of unintended negative consequences related to opinions of AMU and AMR. However, social desirability bias was unlikely to have affected producers enrolled in the study due to their long-term participation with the surveillance network and consistency of attitudes, including those prior to implementation of new regulations and increased public spotlight.

Selection bias is also a potential limitation of this study. Participating herds enrolled in the study were part of a surveillance network and were likely relatively progressive, well-managed herds, since network enrollment criteria included basic record keeping and participation in industry best management practices. Thus, although these data provided some insights into producer attitudes in the Canadian cow-calf industry, they reflect only 1 segment of the industry: those herds of similar size and comparable management practices. In addition to the size of the study, similarity among participants may have limited the power to detect factors associated with attitudes to AMU and AMR. The increased need for and use of antimicrobials, reflected by larger herd size and reporting > 5% of animals treated with antimicrobials, were the only 2 identified factors associated with attitudes toward AMU and AMR.

In conclusion, most survey participants seemed satisfied with access to antimicrobials and their AMU has not changed since the regulatory changes. Veterinary advice was important to many producers in choosing whether to treat with antimicrobials and when dealing with a perceived treatment failure. This was congruent with a previous survey, and implied that cow-calf producers' usage of veterinarians and herd health activities could be increasing (21). In a previous survey of western Canadian cow-calf producers, herd owners who dealt with higher frequencies of scours and pneumonia treatments were more likely to seek veterinary advice (22). Furthermore, that study reported that western Canadian cow-calf producers with larger herds were more likely to seek veterinary advice for treating sick calves (22). As cow-calf herds consolidate and become larger, veterinarians will continue to have an important and potentially increasing role in advising producers regarding disease management, AMU, and stewardship.

Remaining research gaps include better identifying which beliefs are most closely linked with behavior and specifically investigating how the reported attitudes are associated with AMU practices of most interest, such as use of drugs of very high importance to human health or use of MIA for disease prevention. The findings could be applied in stewardship programs to promote desirable practices. Identifying questions or scales to allow identification of producers approaching the inflection point between "no" and "yes" on questions regarding these behaviors (7), or the attitudes that are their closest antecedents, could also be useful to veterinarians in their ongoing promotion of stewardship. CVJ

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