Canadian physicians' knowledge and counseling practices related to antibiotic use and antimicrobial resistance

Two-cycle national survey

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Abstract

Objective To establish a baseline for physicians' knowledge of and counseling practices on the use of antibiotics and antimicrobial resistance (AMR), and to determine potential changes in these measures after the implementation of a national AMR awareness campaign.

Design Cross-sectional design.

Setting Canada.

Participants A total of 1600 physicians.

Main outcome measures Physicians' knowledge of and counseling practices on antibiotic use and AMR at baseline and after implementation of the AMR awareness campaign.

Results A total of 336 physicians responded to the first-cycle survey (before the campaign), and 351 physicians responded to the second-cycle survey (after the campaign). Overall, physicians' knowledge of appropriate antibiotic use and AMR was high and their counseling practices in relation to antibiotics were appropriate in both surveys. Counseling levels about topics related to infection prevention and control (eg, food handling, household hygiene) were slightly lower. Counseling levels were also lower for certain antibiotic-use practices (eg, proper disposal of antibiotics). In addition, physicians with less than 10 years of practice experience had significantly lower odds of counseling their patients on topics related to preventing antibiotic resistance and infection prevention than those with 15 or more years of practice experience (adjusted odds ratio=0.27, 95% CI 0.10 to 0.74). Significantly more physicians from the second-cycle survey counseled patients on the appropriate disposal of antibiotics (P=.03), as well as on some of the infection prevention topics (eg, using antibacterial hand soap [P=.02] and cleaning supplies [P=.01]). Most respondents in both surveys reported feeling confident with respect to counseling their patients on the appropriate use of antibiotics and AMR.

Conclusion Physicians' knowledge of and levels of counseling on the use of antibiotics and AMR were high and fairly stable in both survey results. This shows that Canadian physicians are demonstrating behaviour patterns of AMR stewardship. Existing gaps in counseling practices might be a result of physicians believing that pharmacists or nurses are addressing these issues with patients. Future national surveys conducted among pharmacists and nurses would contribute to the evidence base for AMR stewardship activities.

EDITOR'S KEY POINTS

- To address antimicrobial resistance (AMR) in Canada, a national antibiotics awareness campaign was implemented. Surveys were administered to physicians before and after the campaign to establish a baseline of their knowledge of and counseling on antibiotics and AMR.
- This study found that physicians' knowledge of antibiotic use and AMR was very high. The overall results suggest that physicians are we ll informed about the spread of resistance.
- Topics least likely to be counseled on included food handling, household hygiene, proper coughing and hand-washing practices, and using hand sanitizer and antibacterial supplies (eg, dish soap); this might be because physicians do not believe these topics are important and might expect that other health care professionals will discuss these topics with patients. While counseling on correct antibiotic use was quite high overall, the counseling levels were lowest for cautioning patients about sharing antibiotics and advising on how to properly dispose of them.

This article has been peer reviewed.
Can Fam Physician 2017;63:e526-35

Les connaissances et les pratiques de consultation des médecins canadiens relativement à l'utilisation des antibiotiques et à la résistance aux antibiotiques

Une enquête nationale en 2 étapes

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Résumé

Objectif Déterminer ce que les médecins savent de l'utilisation des antibiotiques et du développement de la résistance aux antibiotiques (RAB), et ce, avant et après l'instauration d'une campagne nationale sur ce problème.

Type d'étude Une enquête transversale.

Contexte Le Canada.

Participants Un total de 1600 médecins.

Principaux paramètres à l'étude Les connaissances et les pratiques de consultation des médecins relativement à l'utilisation des antibiotiques et à la résistance aux antibiotiques, au point de départ et après la mise en œuvre d'une campagne de sensibilisation à la RAM.

Résultats Au total, 336 médecins ont répondu au premier cycle du sondage (avant la campagne) et 351 au deuxième cycle du sondage (après la campagne). Dans les deux sondages, les répondants ont démontré qu'ils connaissaient bien la façon correcte d'utiliser les antibiotiques et la RAB, et leurs pratiques de consultation relatives aux antibiotiques étaient appropriées. Toutefois, pour des sujets comme la prévention et le contrôle des infections (p. ex. la manipulation des aliments et l'hygiène domestique), le counseling était un peu plus faible. Et c'était aussi le cas pour certaines pratiques d'utilisation des antibiotiques (p. ex. la façon d'en disposer). De plus, par rapport aux médecins qui avaient 15 années ou plus de pratique, ceux qui en avaient moins de 10 récoltaient des cotes moins élevées pour leur façon de conseiller les patients sur des sujets liés à la prévention de la résistance bactérienne aux antibiotiques et à la prévention des infections (rapport de cotes ajustée=0.27, IC à 95% 0,10 à 0,74). Un nombre significativement plus élevé de répondants au deuxième cycle du sondage conseillaient leurs patients sur la façon correcte de disposer des antibiotiques (P=.03), mais aussi sur certains sujets concernant la prévention des infections (p. ex. l'utilisation de savons antibactériens pour les mains [P=0,2] et le nettoyage des instruments [P=,01]). La plupart des répondants aux deux sondages se disaient confiants pour ce qui est de conseiller leurs patients sur la façon appropriée d'utiliser les antibiotiques et sur la RAB.

Conclusion Les deux sondages ont montré que les médecins avaient une bonne connaissance de l'utilisation des antibiotiques et de la RAB, et que les conseils qu'ils donnaient à leurs patients étaient appropriés. Cela montre que les médecins canadiens font preuve d'un comportement adéquat quant à la gestion de la RAB. Certaines failles dans leurs pratiques de consultation pourraient résulter du fait qu'ils croient que les pharmaciens ou les infirmières abordent ces questions avec les patients. De futurs sondages nationaux auprès de pharmaciens et d'infirmières pourraient contribuer à la base de connaissances relative aux activités de gestion de la RAB.

POINTS DE REPÈRE DU RÉDACTEUR

- Une campagne nationale de sensibilisation aux antibiotiques a été mise sur pied au Canada pour s'attaquer à l'accroissement de la résistance aux antibiotiques (RAB). On a tenu des sondages auprès de médecins avant et après cette campagne afin d'établir une base de leurs connaissances et des conseils qu'ils donnent relativement aux antibiotiques et sur la RAB.
- Cette étude a montré que les médecins ont une très bonne connaissance de l'utilisation des antibiotiques et de la RAB. Dans l'ensemble, les résultats donnent à croire que les médecins sont bien informés de l'augmentation de la RAB.
- Les sujets le moins susceptibles de faire l'objet de conseils sont la manipulation des aliments, l'hygiène domestique, la bonne façon de tousser et de se laver les mains ainsi que l'utilisation de produits désinfectants et antibactériens (p. ex. le savon à vaisselle); cela pourrait être dû au fait que les médecins ne croient pas que ces sujets sont importants et qu'ils s'attendent à ce que d'autres professionnels de la santé les abordent avec les patients. Les conseils sur l'utilisation correcte des antibiotiques étaient généralement très bien prodigués, mais ceux concernant le partage d'antibiotiques et la façon correcte d'en disposer l'étaient beaucoup moins.

Cet article a fait l'objet d'une révision par des pairs.
Can Fam Physician 2017;63:e526-35

Antimicrobial resistance (AMR) occurs when bacteria, viruses, fungi, and parasites change in such a way that the medications used to eliminate these organisms become less effective.[1-3] Antimicrobial resistance presents a serious public health concern, as it threatens our ability to effectively treat infectious diseases. To address this concern, studies conducted in the United Kingdom,[4] Sweden,[5] Ethiopia,[6] Peru,[7] Spain,[8] Korea,[9] Brazil,[10] and the United States[11] have gathered data on physician knowledge of, beliefs about, and practice patterns for the use of antibiotics and AMR.

Despite this wealth of international literature, there is a lack of concrete data about Canadian physicians' knowledge of and counseling practices regarding antibiotics and AMR. While related studies on antibiotic overprescribing have been done at the provincial level,[12,13] no surveys related to these topics have been conducted about physicians at the national level. This paucity of data is a considerable limitation in conducting effective knowledge translation activities and developing guidance related to AMR.

To address AMR in Canada, the Government of Canada dedicated funds to pilot an antibiotics awareness campaign through the Public Health Agency of Canada. The objectives of the campaign were to improve physicians' knowledge of the potential risks associated with the inappropriate use of antibiotics, and to improve the capacity and confidence of physicians to discuss AMR with their patients. Multiple media platforms were used to promote campaign messages over several months, starting in November 2014.[14] A suite of resources and knowledge products, such as webinars, campaign posters, and Government of Canada Web content was developed and provided to health care professionals. These newly developed resources were promoted in a variety of ways, ranging from social media, news outlets (eg, online, radio, and print), Web banner ads on select sites targeted to health care professionals, and search engine marketing.

In order to establish a baseline of physicians' antibiotic knowledge and counseling practices, and later assess the effect of the campaign, an evaluation was planned to collect first-cycle (before the campaign) and second-cycle (after the campaign) data. The first-cycle survey was conducted in February to March of 2014, while the second-cycle survey was administered in March to April of 2015, 4 months after the launch of the campaign. The objective of the surveys was 2-fold: to establish a baseline for Canadian physicians' knowledge and counseling practices in relation to use of antibiotics and AMR, and to determine potential changes in these measures after implementation of the national AMR awareness campaign.

METHODS

Approval for the research protocol was granted by Health Canada's Research Ethics Board and the appropriate provincial, territorial, and regional boards.

First-cycle survey

A panel of approximately 1600 physicians living and practising in Canada was invited to participate. The contractor for this survey, TNS Canada Ltd, provided the panel of 1600 physicians, who were all Canadian, were from a variety of medical specialties, and were on the panel because of an expressed interest in participating in research. Physicians had to counsel on or prescribe antibiotics in their practice in order to be eligible for the study. All physicians on the panel were contacted by TNS Canada Ltd using e-mail invitations, and respondents were those who met the eligibility criteria and agreed to participate. Respondents were required to provide informed consent before being directed to the survey. There was a nominal remuneration of $40 for the participating physicians.

The survey was available between February 18, 2014, and March 10, 2014, and administered online in English or French. The survey was divided into 4 sections: demographic characteristics, practice and patient interaction, knowledge about AMR, and antibiotic counseling intentions and confidence. The survey was developed internally at the Public Health Agency of Canada by a team of policy analysts, epidemiologists, knowledge translation experts, and communication and marketing experts. The survey was also pilot-tested internally and was reviewed by the Health Canada Research Ethics Board.

Second-cycle survey

The same survey and methodology was used for the second-cycle survey. The survey was administered between March 28, 2015, and April 9, 2015, 4 months after the launch of the campaign. The same panel of approximately 1600 physicians living and practising in Canada was invited to participate. All physicians were eligible to complete the survey, regardless of whether they had completed the first-cycle survey. As a result of this methodology, the 2 samples were neither matched, nor completely independent.

Analyses

The first- and second-cycle surveys were designed to be able to detect a 10% improvement in knowledge and practice. To compare responses between the first- and second-cycle surveys, χ^2 tests were used, and significant differences were set at an α level of .05. When the assumptions for the χ^2 test were violated, a Fisher exact test was performed. Select multivariate analyses were also conducted on the second-cycle survey results.

RESULTS

Demographic characteristics

A total of 359 physicians (22% response rate) participated in the first-cycle survey and 354 (22% response rate) participated in the second-cycle survey. Because there was a small number of non–family physician specialists who participated in each survey (n=23 in the first cycle; n=3 in the second cycle), and owing to the diversity of their specialties, non–family physician specialists were removed from the analysis and only family physicians were included. Thus, the final sample size for the first- and second-cycle surveys was 336 and 351, respectively (**Table 1**). Respondents were predominantly men (71% in the first cycle and 76% in the second cycle), practising in areas with a population of 100 000 or more residents (64% and 69%, respectively), and practising for 15 years or more (70% and 77%, respectively). There were no significant differences between the first- and the second-cycle surveys in sex distribution (P=.14), practice setting (P=.34), or years of practice (P=.06). However, region of practice was statistically different between the 2 cycles (P=.04), with slightly greater representation from the Prairies (Alberta, Saskatchewan, and Manitoba), British Columbia, and Ontario in the second-cycle survey compared with the first. All further analyses will be pooled over regions and multivariate analyses will be adjusted for region.

Prescribing practices and knowledge

Physicians' reasons for prescribing antibiotics. In the first-cycle survey, 92% of respondents indicated that they frequently prescribed antibiotics for respiratory infections, followed by urinary tract infections (69%), skin infections (54%), sexually transmitted infections (33%), prophylaxis (17%), and digestive tract infections (12%). In the second-cycle survey, these results changed very little (**Figure 1**). There were no significant differences between the first- and the second-cycle survey results in the percentage of respondents who reported that they frequently prescribed antibiotics for each condition.

Physicians' knowledge about issues relating to antibiotic resistance. To assess their knowledge of AMR, respondents were asked true-false questions regarding the development and spread of resistance (**Table 2**). Of the 10 questions that were asked, respondents answered at least 9 of them correctly 87% of the time in the first-cycle survey and 91% of the time in the second-cycle survey.

Despite these overall positive results, 14% of respondents in the first-cycle survey and 16% in the second-cycle survey falsely believed that AMR occurs when *people* become resistant to antibiotics; however, it is the bacteria and invasive organisms that develop resistance, not humans (7% and 4% responded "don't know" in the first and second cycles, respectively). In addition, 11% of respondents in the first-cycle survey and 9% of respondents in the second-cycle survey either didn't know the answer, or responded incorrectly as to whether AMR can increase as a result of patients not taking their full course of antibiotics (indeed, AMR can increase as a result of this). This question was also the only question that showed a statistically significant difference in responses between cycles (P=.04). Between the first and second cycles, there was a 2% increase in correct responses, a 4% decrease in incorrect responses, and a small corresponding increase in "don't know" responses.

Counseling: topics and physician confidence

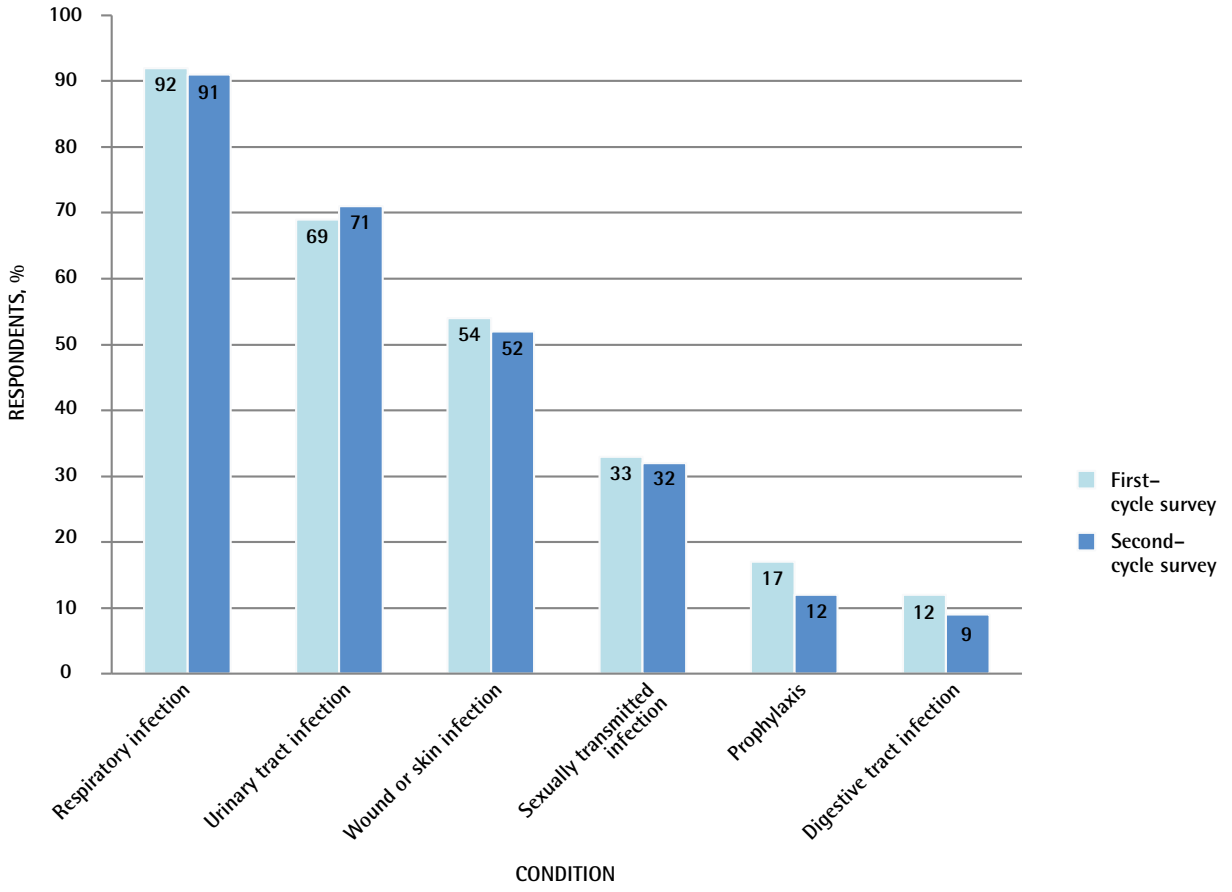
Counseling on topics related to preventing antibiotic resistance and infection prevention. Respondents in both

Table 1. Demographic characteristics of the participants in the first-cycle and second-cycle surveys: *There were 336 participants in first cycle and 351 participants in the second cycle.*

VARIABLE	FIRST-CYCLE SURVEY, N (%)	SECOND-CYCLE SURVEY, N (%)	*P* VALUE
Sex			.14
• Male	240 (71)	268 (76)	
• Female	96 (29)	83 (24)	
Region			.04*
• Atlantic†	27 (8)	21 (6)	
• Quebec	77 (23)	52 (15)	
• Ontario	123 (37)	141 (40)	
• Prairies‡	59 (18)	71 (20)	
• British Columbia	50 (15)	66 (19)	
Years of practice			.06
• < 5 y	17 (5)	15 (4)	
• 5-9 y	32 (10)	32 (9)	
• 10-14 y	52 (15)	35 (10)	
• ≥ 15 y	235 (70)	269 (77)	
Practice setting (population)			.34
• Large urban centre (≥ 100 000)	216 (64)	243 (69)	
• Medium centre (30 000-99 999)	57 (17)	55 (16)	
• Small urban or suburban centre (1000-29 999)	50 (15)	46 (13)	
• Rural area (< 1000)	12 (4)	7 (2)	
• Geographically isolated or remote	1 (0)	0 (0)	

*Significant at the .05 α level.
†Atlantic provinces comprise Nova Scotia, Prince Edward Island, and New Brunswick.
‡Prairie provinces comprise Manitoba, Saskatchewan, and Alberta.

Figure 1. Percentage of respondents who reported frequently prescribing antibiotics, by condition



survey cycles were asked about how often they counseled patients on topics related to preventing antibiotic resistance and infection prevention. Respondents were presented with a list of 10 topics, ranging from influenza vaccination and hand hygiene, to safe sex and food handling. Respondents had 4 answers to choose from: "often," "sometimes," "almost never," and "don't remember."

Overall, 99% of respondents in both the first- and second-cycle surveys reported often or sometimes discussing the annual influenza vaccination program with patients. A high percentage of respondents in both surveys also reported having discussions with patients about safe sex, coughing practices, and hand-washing practices. Food handling, household hygiene, and the use of hand sanitizer were topics that were less frequently addressed by physicians. The topics discussed the least were the use of antibacterial dish soap, antibacterial hand soap, and antibacterial cleaning supplies (**Figure 2**).

In 8 out of the 10 topics, there were no significant differences in responses between the first- and second-cycle surveys. However, significantly more respondents reported often or sometimes counseling patients on using antibacterial hand soap ($P=.02$) and antibacterial cleaning supplies ($P=.01$) in the second-cycle survey compared with the first cycle. In addition, logistic regression analyses revealed that physicians with less than 10 years of practice experience had significantly lower odds of counseling patients on all 10 topics (versus 9 or fewer) compared with those with 15 or more years of practice experience (adjusted odds ratio=0.27, 95% CI 0.10 to 0.74).

Counseling on correct antibiotic use. Respondents in both cycles were asked about how often they counseled patients about correct antibiotic use and were presented with a list of 5 topics. Respondents had 4 answers to choose from: "often," "sometimes," "almost never," and "don't remember."

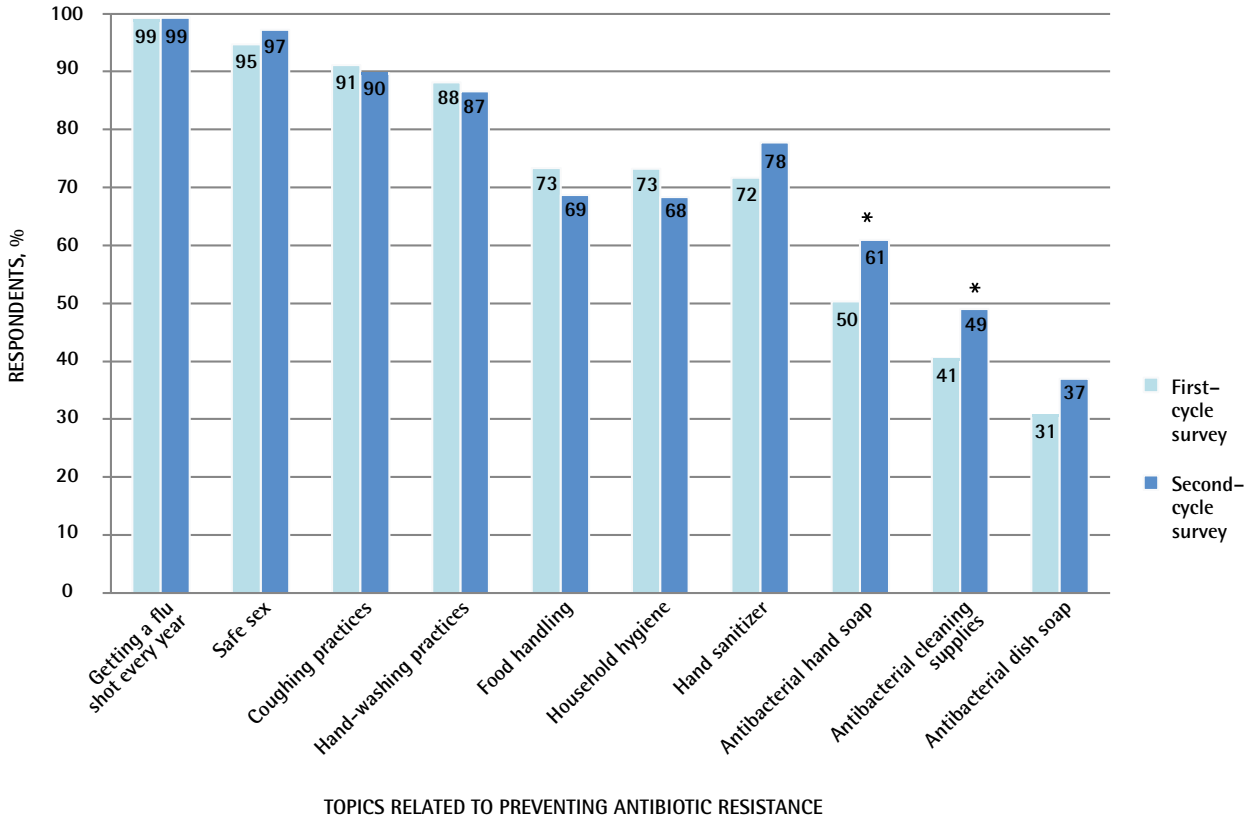
Ninety-nine percent of respondents in both the first- and second-cycle surveys reported that they often or sometimes counsel their patients about the correct daily dose and length of the prescription of antibiotics, or why an antibiotic is not being prescribed (ie, that antibiotics are only effective for the treatment of bacterial infections). Respondents from both cycles also reported high levels of counseling their

Table 2. Percentage of respondents correctly answering true-false questions related to antimicrobial resistance

TRUE-FALSE QUESTIONS	CORRECT ANSWER	RESPONDENTS WHO ANSWERED CORRECTLY, %		*P* VALUE (ALL CATEGORIES OF RESPONSE*)
		FIRST-CYCLE SURVEY	SECOND-CYCLE SURVEY	
Use of antibiotics is associated with disturbance of the normal microbial flora	True	97	98	.76
The following factor increases AMR: patients not taking their full course of antibiotics	True	89	91	.04†
The following factor increases AMR: bacteria adapting rapidly to new conditions	True	98	95	.21
The following factor increases AMR: patients taking antibiotics when not necessary	True	98	99	.08
Antibiotic resistance occurs when people become resistant to antibiotics	False	79	80	.35
Antibiotic resistance occurs when bacteria become resistant to antibiotics	True	99	98	> .99
Proper hand-washing technique prevents spread of organisms that are on the hands	True	96	98	.35
When one gets a cold, antibiotics will help one get better more quickly	False	95	97	.24
If someone you know is not feeling well, it is safe to share antibiotics with them	False	96	98	.51
If someone in a household is sick, taking antibiotics will prevent other household members from getting sick	False	87	90	.31

AMR—antimicrobial resistance.
*Analyses were conducted by comparing all response categories between the first- and second-cycle surveys (ie, correct, incorrect, "don't know"), not just the correct responses.
†Significant at the .05 α level.

Figure 2. Percentage of respondents who indicated that they "often" or "sometimes" address topics related to preventing antibiotic resistance with their patients during a consultation



*Significant at the α level of .05.

patients not to use antibiotics that belong to others and not to share antibiotics. How to dispose of leftover antibiotics was discussed least often in both cycles (**Figure 3**).

Significantly more respondents reported often or sometimes counseling patients on how to dispose of leftover antibiotics in the second-cycle survey compared with the first-cycle survey ($P=.03$). Logistic regression analyses revealed that all physicians, regardless of demographic characteristics (eg, sex, years of practice, practice setting), were equally likely to counsel their patients on all 5 topics that related to antibiotic use (versus 4 or fewer).

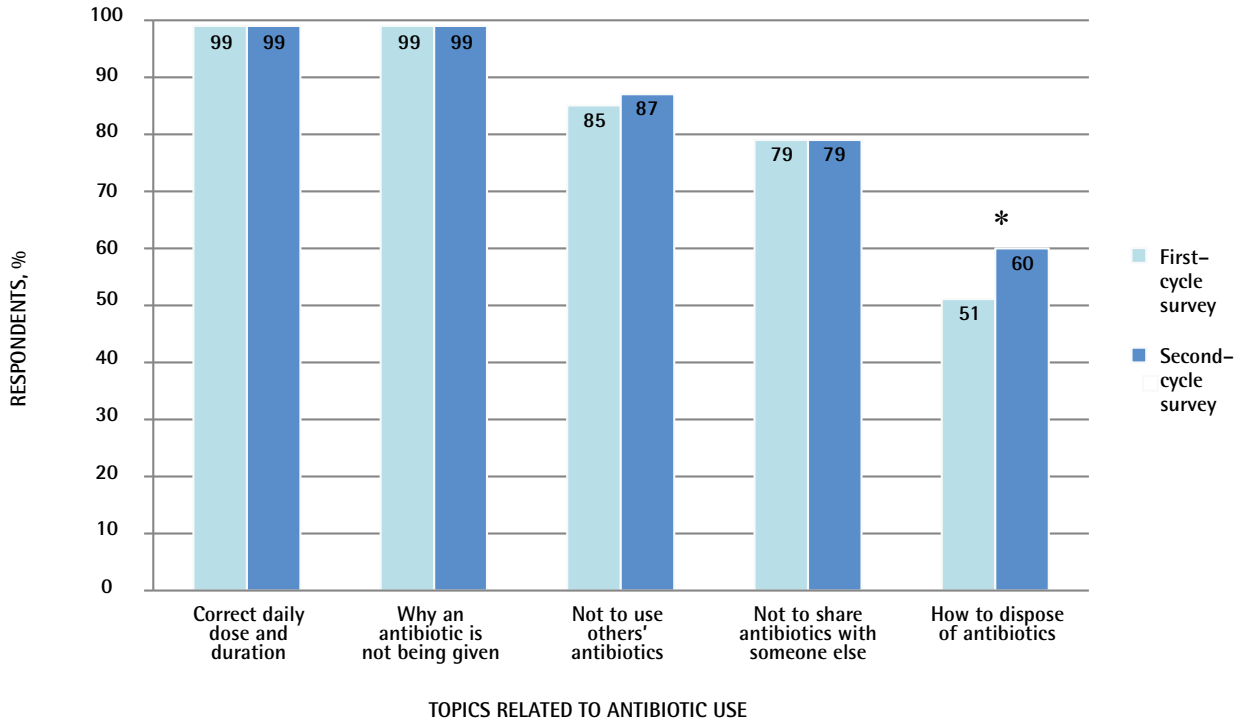
Topics discussed during the last consultation for a viral respiratory infection. Respondents were then asked to think back to their last consultation for a suspected viral respiratory tract infection and to report whether they had discussed certain topics related to infection prevention and the appropriate use of antibiotics. Available responses were "yes," "no," "unsure," and "not applicable to visit."

Ninety-four percent of first-cycle survey respondents and 95% of second-cycle survey respondents reported that they addressed the fact that antibiotics are only effective in treating bacterial infections. The second most frequently discussed topic shown in both survey results was participation in an annual influenza immunization program (70% of respond-ents in the first cycle; 71% in the second cycle). Hand-washing practices were discussed by 59% of respondents in the first-cycle survey and 55% in the second. Last, correct coughing practices were addressed by approximately 60% of respondents, with similar levels among the first- and second-cycle survey respondents (61% and 56% in the first and second cycle, respectively). There were no significant differences between the first and second cycle in any of the topics discussed. In addition, logistic regression revealed that all physicians, regardless of demographic characteristics (eg, sex, years of practice, practice setting), were equally likely to counsel their patients on all 4 topics (versus 3 or fewer) during their last consultation for a viral respiratory infection.

Physicians' confidence about specific counseling topics. Respondents were asked to rate their confidence with respect to counseling patients about topics related to the appropriate use of antibiotics and the prevention of AMR. Available answers were "very confident," "somewhat confident," "neutral," "somewhat not confident," "not confident at all," and "don't know."

When the categories "somewhat confident" and "very confident" were combined, at least 95% of physicians

Figure 3. Percentage of respondents who indicated that they "often" or "sometimes" address topics related to antibiotic use with their patients during a consultation



*Significant at the α level of .05.

responded that they were confident in discussing the fact that antibiotics are for bacterial infections (99% in the first cycle, 98% in the second cycle); providing a strong rationale for not prescribing antibiotics (99% and 98%, respectively); discussing the annual influenza vaccination program (98% and 99%, respectively); discussing proper antibiotic use and prevention of AMR (97% in both cycles); refusing to give an unnecessary prescription for antibiotics (96% and 95%, respectively); and counseling their patients on safer sex (95% and 97%, respectively). At least 91% of respondents in both cycles were confident in providing counseling on hand hygiene and coughing practices, but respondents in both cycles were less confident about counseling on household infection control (77% in both cycles) and food handling (72% and 69%, respectively). There were no significant differences between the first and second cycle in physicians' confidence related to the 10 specific counseling topics discussed above.

DISCUSSION

Knowledge and behaviour among physicians remained relatively stable across survey cycles. Based on the impressive results of the first-cycle survey, it was not realistic to observe a large difference in the second-cycle survey. The stability across cycles does provide confidence in results, and fulfils the surveys' primary intention, which was to establish baseline data for Canadian physicians' knowledge of and counseling practices on the use of antibiotics and AMR.

The response rate for both survey cycles was 22%. This is comparable to other surveys using similar methods and similar samples.[15] However, this response rate might be artificially low, as the online survey was taken offline as soon as the desired sample size (ie, N = 350) was reached. The samples from both survey cycles were predominantly men, were from urban centres, and had 15 or more years of practice experience. This distribution is fairly representative of the Canadian physician population.[16] The high representation of physicians from urban centres and with 15 or more years of practice experience is of note, however, as some literature indicates that those with more time in practice and higher patient volumes are more likely to prescribe antibiotics inappropriately.[17,18] However, the results of this survey suggest that Canadian physicians are demonstrating behaviour patterns of AMR stewardship (eg, patient counseling, refusal to give inappropriate antibiotics). The discrepancy between the research literature and the results of this survey might indicate the presence of social desirability bias in the survey responses. Alternatively, the discrepancy might indicate that physician behaviour and attitudes toward antibiotics has changed since the noted publications (ie, 2007 and 2012). This would not be unrealistic, considering the increased focus on AMR and antibiotic use in recent years.

In general, physicians' knowledge of antibiotics and AMR was very high; however, a small group of respondents falsely believed that AMR occurs when *people* become resistant to antibiotics (rather than the bacterium or organism becoming resistant). This might have occurred because of the way the question was worded, an assumption supported by the high rate of correct answers to other questions. Overall, the results suggest that physicians are well informed on the development and spread of resistance.

As expected, the conditions for which physicians frequently prescribe antibiotics remained consistent between surveys. These results also align with Canadian surveillance data on physician prescribing patterns, providing confidence in our survey results.[19]

Topics with the lowest levels of consultations included food handling, household hygiene, the use of hand sanitizer, proper coughing practices, proper handwashing practices, and the use of antibacterial dish soap, antibacterial hand soap, and antibacterial cleaning supplies. Counseling on these topics might be lower in relation to other topics because physicians do not feel as though these topics are important. Alternatively, physicians might expect that nurses will discuss these prevention and education topics with patients. A survey on nurses' knowledge of and behaviour patterns regarding AMR-related prevention and education counseling might be useful to provide insight in this area.

While specific counseling on correct antibiotic use was quite high overall, the levels were lowest for cautioning patients about sharing antibiotics and providing advice regarding the proper disposal of antibiotics. Significantly more respondents reported counseling patients on proper disposal of antibiotics in the second-cycle survey compared with the first cycle ($P = .03$); however, the percentage of physicians who reported counseling on this topic still remained relatively low. A patient might have leftover antibiotics if he or she experiences an adverse reaction to a medication or if test results require a change in prescription. It is possible that physicians are not discussing these topics because they consider them counterintuitive to the messaging about using all of the prescribed medication. Physicians might also expect that pharmacists will discuss these topics at the point of sale. A survey on pharmacist knowledge and behaviour related to antibiotic use and counseling might provide helpful insight in this area. In addition, creating a checklist of appropriate counseling topics for family physicians might be helpful to ensure fulsome counseling occurs in the office setting.

Limitations

Online surveys are associated with limitations. Physicians who agree to participate in research panels could be more aware of and interested in public health subjects than the average physician, resulting in selection bias. However, relevant work on physician-based survey research suggests that no systematic bias manifests from the use of panel samples.[20] Other potential limitations of the study include social or professional desirability bias, recall bias, varying interpretations of questions, unintentional ambiguity in question phrasing, and the use of closed-ended questions. In addition, the results rely on self-reported responses and self-assessments; actual physician behaviour might differ.

Finally, there are several limitations in interpreting the results of the first-cycle and second-cycle surveys. The 2 samples were neither matched nor completely independent. While much of the second-cycle sample is likely unique from the first, there might be some overlap if physicians agreed to answer both survey requests. The degree of overlap could not be definitively determined owing to the confidential nature of the responses. Because the samples were not independent, multivariate analyses were not pooled over survey cycles. Thus, all multivariate analyses were conducted with the second-cycle sample as its data source. Without pooling, the sample size for the multivariate analyses was reduced by half, and thus some statistical power was lost. Because the samples were not matched, differences between the first- and second-cycle surveys could have resulted from various factors, including both random and systematic differences in the physicians selected for the first-cycle sample and second-cycle sample. Instead of a traditional "pre" and "post" longitudinal design, these surveys should instead be considered 2 cross-sectional surveys at 2 different time points.

Conclusion

Although the study is subject to limitations, the relative stability in results across both the first- and second-cycle surveys provides confidence that the study met its primary objective (ie, establishing a baseline for the knowledge and counseling practices of Canadian physicians related to the use of antibiotics and AMR). According to the results of the survey, Canadian physicians were knowledgeable about the appropriate use of antibiotics and AMR, and were confident in discussing these topics with their patients. Existing gaps in physician counseling on select AMR-related topics might be a result of the belief that pharmacists or nurses are addressing these issues with patients. Obtaining information on the knowledge and behaviour patterns of these groups of health care professionals might be advantageous.

This study serves as the first national survey of its kind, contributing much-needed exploratory research into the knowledge and counseling practices of Canadian physicians as it relates to antibiotics and AMR. These results can serve to inform policy makers in their development of AMR campaigns and guidelines in both the Canadian context and beyond.

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Contributors

Ms Smith contributed to data analysis and interpretation, as well as drafting of the manuscript. **Ms Pogany, Mr Foley, Dr Wu, Ms Timmerman,** and **Dr Gale-Rowe** contributed to data acquisition and interpretation, as well as critical revisions to the manuscript. **Dr Demers** contributed to the study conception and design, data acquisition, and critical revisions to the manuscript. All authors approved the final version for publication.

Competing interests

None declared

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