



Original Article

Remote Monitoring of Cardiovascular Implantable Electronic Devices in Canada: Survey of Patients and Device Health Care Professionals

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ABSTRACT

Background: Remote monitoring is used to supplement in-clinic follow-up for patients with cardiac implantable electronic devices (CIEDs) every 6–12 months. There is a need to optimize remote management for CIEDs because of the consistent increases in CIED implants over the past decade. The objective of this study was to investigate real and perceived barriers to the use of remote patient management strategies in Canada and to better understand how remote models of care can be optimized. **Methods:** We surveyed 512 CIED patients and practitioners in 22 device clinics in Canada.

Results: Device clinic surveys highlighted significant variation and inconsistency in follow-up care for in-clinic and remote visits across

RÉSUMÉ

Introduction : La télésurveillance sert de complément à la consultation en clinique des patients porteurs d'un dispositif cardiaque électronique implantable (DCEI) tous les 6 à 12 mois. Il est nécessaire d'optimiser la prise en charge à distance des patients porteurs de DCEI en raison de la constante augmentation des implantations de DCEI au cours de la dernière décennie. L'objectif de la présente étude était d'examiner les obstacles réels et perçus à l'utilisation des stratégies de prise en charge à distance des patients du Canada et de mieux comprendre la façon d'optimiser les modèles de soins à distance.

Méthodes : Nous avons interrogé 512 patients porteurs de DCEI et praticiens de 22 cliniques spécialisées en DCEI du Canada.

Canada is a country with a diverse geography, of which 19% of the inhabitants are in communities classified as “rural,” but many might still have long distances to travel to reach a health care facility.¹ This results in challenges in uniform delivery of

health care throughout the country. There are 25,000 pacemaker and 7000 implantable cardioverter defibrillator (ICD) implants yearly in Canada, with approximately 120,000 patients living with these cardiovascular implantable electronic devices (CIEDs).^{2,3} Remote monitoring is a form of virtual patient care that occurs at a distance and involves interaction between a patient and their care team using an information technology to exchange device information.⁴ In patients with CIEDs, remote monitoring is used for passive transmission of device diagnostics and/or programmed alerts or transmission of device information by manual patient activation whereby the information is then accessed from a Web site by clinic staff.⁵

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Ethics Statement: The reported research has adhered to the relevant ethical guidelines.

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See page 398 for disclosure information.

and within clinics. This survey showed that funding policies and management of additional workflow are barriers to optimal use and uptake. Despite this, device clinics perceive remote follow-up as a valuable resource and an efficient way to manage patient follow-up. Patients were broadly satisfied with their CIED follow-up care but identified barriers related to coordination of care, visit logistics, and information needs. Views varied as a function of clinical or socio-demographic characteristics. Most patients ($n = 228$; 91%) expressed a desire to receive a phone call from their device clinic after a remote transmission has been received.

Conclusions: Lack of a unified, guideline-supported approach to follow-up after CIED implant, and discrepant funding policies across jurisdictions, are significant barriers to the use of remote patient management strategies in Canada. Efforts to increase or expand use of remote follow-up must recognize these barriers and the needs of specific subgroups of patients.

Evidence has shown that remote monitoring can improve patient and health care system outcomes.⁵⁻¹⁰ It can reduce the time to diagnosis or therapeutic intervention for patients, which in turn reduces emergency room visits, hospitalizations, and mortality. Canadian guidelines recommend patients who receive CIEDs undergo routine device follow-up assessment of their CIED at regular intervals.¹¹ A recent position statement from the Canadian Cardiovascular Society and Canadian Heart Rhythm Society endorse remote monitoring for the routine follow-up of CIED patients for whom no active device issues are identified. Ideally, remote monitoring is blended with in-clinic assessments beginning after the initial post implantation assessment,³ although schedules differ for pacemakers and ICDs. Although remote monitoring technology is currently available from any patient location accessible to a land line or mobile phone, use has been inconsistent in Canada. In 2013, only 8500 of a potential 120,000 patients with CIEDs were enrolled in this program.¹² Technological advancements now permit more comprehensive remote patient follow-up beyond the usual diagnostic and monitoring functionality. Technology and software system innovation now allow device care teams to move beyond one-way information capture to a two-way system, which enables more comprehensive patient management at a distance.

To date, poor uptake of remote monitoring might be attributable to a number of health system, patient, device clinic, or technology-related factors.¹³ These barriers are a challenge to broad implementation of remote management programs for patients with CIEDs in Canada. If these existing models of care are to expand to a more comprehensive remote program of follow-up, additional barriers might also interfere with the uptake of this approach. We surveyed CIED patients and device clinics across Canada to investigate real and perceived barriers to the use of remote patient management

Résultats : Les enquêtes des cliniques spécialisées en DCEI ont fait ressortir la variation importante et le manque d'uniformité dans les soins de suivi lors des consultations en clinique et à distance au sein de toutes les cliniques et entre elles. Cette enquête a montré que les politiques de financement et la gestion du flux de travail supplémentaire sont les obstacles qui empêchent l'utilisation optimale et l'adoption. Malgré cela, les cliniques spécialisées en DCEI perçoivent le suivi à distance comme une ressource très utile et un moyen efficace de prendre en charge le suivi du patient. Les patients étaient dans l'ensemble satisfaits de leurs soins de suivi relatifs à leur DCEI, mais relevaient des obstacles liés à la coordination des soins, à la logistique des consultations et à leurs besoins d'information. Les points de vue variaient en fonction des caractéristiques cliniques et socio-démographiques. La plupart des patients ($n = 228$; 91 %) ont fait part de leur souhait de recevoir un appel téléphonique de leur clinique spécialisée en DCEI après la réception de la transmission à distance. **Conclusions :** L'absence d'une approche unifiée et fondée sur les lignes directrices qui porte sur le suivi après l'implantation de DCEI, et la divergence des politiques de financement des provinces et territoires sont des obstacles importants à l'utilisation de stratégies de prise en charge à distance des patients au Canada. Les efforts visant à accroître ou à étendre l'utilisation du suivi à distance doivent tenir compte de ces obstacles et des besoins des sous-groupes particuliers de patients.

strategies in Canada and to better understand how remote models of care can be optimized.

Methods

Ethics approval for the 2 cross-sectional surveys was obtained through the appropriate institutional review boards. The cross-sectional survey questionnaires were developed by an experienced team of electrophysiologists, patient council, and allied health professionals from Dalhousie University and the University of Calgary using an iterative development process for item generation and reduction. A patient steering group ($n = 6$ patient advisors) was actively involved with questionnaire development and refinement. English questionnaires were translated into French before survey administration (see [Supplemental Appendices S1 and S2](#)).

Device clinic survey

In 2015, a multicentre survey of CIED clinics was conducted in 5 provinces in Canada (British Columbia, Alberta, Ontario, Quebec, Nova Scotia). Device clinics were eligible if they performed CIED implants and/or provided or managed outpatient care, education, or regular evaluation for pacemaker, ICD, or cardiac resynchronization therapy (CRT) patients in Canada.

We approached device clinics in Canada ($n = 29$) via e-mail to participate in the survey. Reminders for nonresponders were sent by e-mail/ followed-up via telephone. Clinics that agreed to participate were enrolled in the study and were not remunerated for their participation. Clinics were asked to complete a secure, Web-based survey hosted on a Research Electronic Data Capture (REDCap) platform. Clinics were asked in the survey to provide information about their clinic and to respond to 17 questions relevant to the use of remote monitoring, patient management, and reimbursement (see the

[Supplemental Appendix S1](#)). These questions related to volume of patients according to type of CIEDs, current use of remote monitoring, vendor, clinic staff, frequency, and type of follow-up for patients with normal device function, reimbursement, clinic-specific follow-up guidelines, concurrent assessment medication review/clinical factors, satellite community clinic use, and response to alerts or change in patients' health status off-hours.

Descriptive statistics (proportion for categorical variables, mean \pm SD, or median/interquartile range for continuous variables) were generated using Microsoft Excel (Microsoft Corp, Redmond, WA), and narrative summaries for text-based responses to open-ended questions were created.

To supplement the survey and to gain a more in-depth understanding of the use and challenges associated with remote monitoring in device clinics in Canada, we conducted semistructured interviews with key informants defined as individuals who were experienced with CIED follow-up and who were using remote monitoring in some capacity in their clinical practice. Detailed methods are reported in full in [Supplemental Appendix S3](#).

Patient survey

To capture patient experience with remote monitoring and perceptions about remote care, we surveyed CIED recipients between May and December 2016 in 3 Canadian provinces (Alberta, Québec, Nova Scotia). Eligible patients were adults aged 18 or older who resided in Canada, had an implanted pacemaker, ICD, or CRT, were able to read and understand English or French, and were able to provide consent.

Participants were recruited through posters and survey information cards placed in device clinic waiting areas. We actively approached consecutive patients in consecutive device clinics in Nova Scotia in person. The survey was administered online and in hard copy format. Online surveys were completed using a secure Web-based application linked to a REDCap platform. Hard-copy survey responses were collected in clinic and then manually entered into the online survey format by research staff. All responses were anonymized and participants were not remunerated for their participation.

All participants who agreed to participate were asked to provide demographic information (age, sex, ethnic background, employment status, first language) and were given 17 questions relating to their individual experiences with their CIED, their follow-up care, and their attitude toward expanding remote patient management (see [Supplemental Appendix S2](#)). The questions included time of first implantation, frequency of perceived device-related issues (and type), their knowledge of what their device does, shock frequency (for ICDs), frequency and type of follow-up post implantation, emotional responses to alerts, and the importance of contact from a device clinic after remote transmissions (if applicable). Participants were asked about travel distance to clinic, requirements for assistance, comfort level, and changes in behaviour. One question addressed patients' preference for in-person device clinic follow-up.

Descriptive statistics (proportion for categorical variables, means \pm SD, or median and interquartile range for continuous variables) were generated and narrative summaries for text-based responses to open-ended questions were created.

Differences according to age, retirement, sex, and distance to clinic province, age, or device type were assessed using χ^2 tests or Cochran-Armitage trend tests (for categorical data) and *t* tests (for continuous data). Further comparisons were made according to shock history and device within the ICD group. Analysis was done using SAS version 9.4 (SAS Institute Inc, Cary, NC).

Results

Device clinic survey

Of the 29 centres contacted, 22 (76%) agreed to participate ([Supplemental Table S1](#) includes a list of participating centres). A physician completed the survey most frequently ($n = 14$), although responses were also received from allied health professionals ($n = 5$), and allied professional clinic managers ($n = 3$). The demographic characteristics of the device clinics are provided in [Table 1](#).

Barriers identified

[Table 2](#) provides a summary of barriers identified through the patient and device clinic surveys.

Patient mix and current use of remote monitoring. The types of CIEDs managed by the clinics included: CRT-pacemaker or biventricular pacemaker (CRT-P; 82%); CRT-defibrillator or biventricular defibrillator (CRT-D; 77%); pacemakers (82%); and ICDs (82%). Remote monitoring was used in 20 (91%) clinics for at least some patients (range, 110-250 patients) as part of their device follow-up strategy for patients. Vendor technology for the remote monitoring technology varied within and among clinics: 100% used Medtronic (Minneapolis, MN), 60% used Abbott/St. Jude (Chicago, IL), 40% used Boston Scientific (Marlborough, MA), 30% used Biotronik (Berlin, Germany), and 20% used ELA Medical (a subsidiary of Sorin; Minneapolis, MN). Six clinics (27%) reported using transtelephonic monitoring or 12-lead electrocardiograms as part of their remote follow-up strategy.

Reimbursement. Remote monitoring reimbursement was present for a small percentage of the device clinics (range, 4-7 clinics) and fees received were dependent on the type of device.

Characteristics of in-clinic or remote visits. In-clinic and remote follow-up varied across Canada. There were significant differences across device clinics in how patients were managed in clinic and through remote visits after receipt of their CIED. For in-clinic visits, the variations were related to the use of clinic-specific patient management guidelines, the type of device, clinical indication, and involvement of vendor representatives. Some adhered to clinic-specific follow-up guidelines that dictate who is to perform the device check and in what circumstances a physician must be involved before sending the patient home (9 clinics; 47%). Doctor-patient interaction during in-clinic visits was dependent on the type of device implanted and whether or not the visit was clinically indicated. Patients with CRT-Ds or ICDs were most

Table 1. Demographic characteristics of device clinic and patient survey participants

Characteristic	n (%)
Device clinic survey (n = 22)	
Province	
Alberta	4 (18.1)
British Columbia	3 (13.6)
Nova Scotia	1 (4.5)
Ontario	10 (45.5)
Quebec	4 (18.1)
Device clinic respondent	
MD clinical director	11 (50.0)
Allied health professional	5 (22.7)
Allied professional/clinic manager	3 (13.6)
Device follow-up physician	3 (13.6)
Currently use remote monitoring	
Yes	20 (90.9)
No	2 (9.1)
Vendors used for remote monitoring	
Medtronic (Minneapolis, MN)	20 (100)
Abbott/St. Jude (Chicago, IL)	12 (60.0)
Boston Scientific (Marlborough, MA)	8 (40.0)
Biotronik (Berlin, Germany)	6 (30.0)
ELA, a subsidiary of Sorin (Minneapolis, MN)	4 (20.0)
Telephone call after remote transmission	
Yes	8 (40.0)
No	12 (60.0)
Patient survey (n = 512)	
Province	
Alberta	35 (6.8)
Nova Scotia	372 (72.7)
Quebec	105 (20.5)
Age, years	
< 19	1 (0.2)
20-29	8 (1.6)
30-39	7 (1.4)
40-49	22 (4.3)
50-59	64 (12.6)
60-69	170 (33.4)
> 70	234 (46.0)
No response	6 (0.09)
Sex	
Male	368 (72.3)
Female	141 (27.7)
First language	
English	373 (73.3)
French	110 (21.6)
Other*	26 (5.1)
Employment status	
Employed full-time	67 (13.2)
Employed part-time	22 (4.3)
Unemployed	13 (2.6)
Retired	355 (70.0)
Other†	49 (9.7%)
Declined response	1 (0.2)
Timing of first CIED implant in years	
< 1	88 (17.2)
1-5	204 (39.8)
6-10	113 (22.1)
> 10	107 (20.9)

CIED, cardiac implantable electronic device.

*Bosnian (n = 1), Chinese (n = 1), Dutch (n = 3), German (n = 4), Greek (n = 1), Hindi (n = 1), Icelandic (n = 1), Lebanese (n = 1), Mi'kmaq (n = 2), Russian (n = 1), Spanish (n = 3), Tagalog (n = 1), Ukrainian (n = 3), English and French (n = 2).

†Twenty-three participants specified that they were receiving disability. Others specified that they were: self-employed (n = 7), a homemaker (n = 1),

a student (n = 3), on parental leave (n = 1), or on medical leave (n = 3). Two specified that s/he was retired but worked part-time or was semiretired. One clarified that retirement was pending (n = 1), another that s/he was a business manager (n = 1), another a company president (n = 1), and another an apartment building owner (n = 1).

frequently reported as seeing a doctor at every visit, whereas patients with CRT-Ps, and pacemakers were more likely to be seen by a doctor only when clinically indicated. Most clinics (range, 68% for CRT to 95% for pacemaker) reported that vendor representatives were present for in-clinic follow-up if they were required by the clinic. Health assessments during in-clinic visits (eg, medication review, activity level check, nutrition) and communication to primary providers also varied across clinics. After an in-clinic visit, some clinics (58%-74% depending on device type) follow-up with a patient's general practitioner by sending an information letter. Most clinics (96%) instructed patients to present to the closest emergency department outside of clinic hours or on weekends if they are feeling unwell and believe it is related to their CIED.

Response to remote transmissions and alerts varied in the device clinics. Seven clinics indicated that when CIED patients experience alerts triggered by remote follow-up, they are instructed to present to the nearest emergency department. Most clinics contacted the patient on the next business day after an alert (77%), whereas few provided an on-call number to contact their device clinic for further instruction. Eight clinics (36%) routinely called patients after a remote transmission was received. Device clinics shared patient care with community-based or satellite device clinics (range, 1-10 satellite clinics/primary device clinic) depending on the type of device (8 clinics [40%] provide sole care for CRT-D/P and ICDs and 10 clinics indicated sole care for pacemaker follow-up).

Patient survey

Population. A total of 512 patients from 3 Canadian provinces (Quebec, Nova Scotia, and Alberta) participated. During active, consecutive enrollment, 12 random full-day clinic investigations at the largest site (Nova Scotia) were used to document patient survey refusal rates. Using this approach, survey refusal rates of between 2% and 5% were recorded. Of the 512 enrolled, 372 (73%) respondents lived in Nova Scotia, 105 (21%) in Quebec, and 35 (7%) in Alberta. Not all participants answered all questions, therefore the total number of responses to each question varies. A total of 498 (97.2%) participants answered all survey questions.

Demographic characteristics of the 512 respondents are shown in Table 1. Patients had pacemakers (n = 138; 27%) or ICDs (n = 248; 73%). CRT-D/P patients were included in the survey but the information regarding their device was classified as either ICD or pacemaker, without knowledge of whether they were a CRT. Time since CIED implantation varied from < 1 year (17%), 1-5 years (40%), 6-10 years (22%), to > 10 years (21%). There were differences noted when demographic characteristics for respondents in Nova

Table 2. Table of barriers identified through patient and device clinic surveys

Barrier identified
1. Inconsistent and/or limited funding policies across jurisdictions for in-clinic and remote visits
2. Lack of a unified, process-specific, and guideline-supported approach to follow-up after CIED implant
3. Accessibility for all patients and types of devices
4. Resources (education, time, training)
5. Coordination of care
6. Visit logistics
7. Attitudes toward remote visits

CIED, cardiac implantable electronic device.

Scotia were compared with those in other provinces (Supplemental Table S2).

Device knowledge and experience. Respondents (81%) reported that their device always works well, with < 1% reporting their device rarely worked well or that they often experience issues. A total of 21% required a battery change. A range of difficulties with devices were reported including lead problems (15%), discomfort (7.8%), multiple surgeries (7%), device recall (4%), infection (2.4%), beep/vibration without warning (4%), skin breakthrough (1.0%), or a complication at implantation (6%). Twenty-nine patients (6%) reported “other” complications or problems, including technical issues and psychological discomfort.

The CIED recipients surveyed were knowledgeable about their device and what it does, although a small proportion (0.2%) responded that “it makes me feel worse,” and clarified in free text comments that they found their CIED unhelpful during certain activities (eg, exercise, meditation). Fifty percent of patients with an ICD had never received a shock. In those who had received a shock from their device, equal proportions had received 1 shock, 2-4 shocks, or ≥ 5 shocks.

Quality of life and device satisfaction. CIED recipients were generally satisfied or very satisfied with their current quality of life (90%). In those who reported being unsure, reasons provided varied according to individual circumstances (eg, not sure the CIED was making any difference [$n = 3$], quality of life was being compromised by issues unrelated to their CIED [$n = 2$], or advice to limit physical activity was noted [$n = 1$]).

Device follow-up and care. Forty-five percent of CIED recipients surveyed lived at a considerable distance (> 50 km) from their device clinic. Of 507 respondents, most (87%) attended a device clinic located in the hospital where their device was implanted. Fifty percent reported use of remote monitoring, and a small proportion (7%) were followed at a clinic closer to their residence that does not do implantations. CIED patients reported attending in-person device clinics every 6 (54%) or 12 months (34%). A small proportion reported being seen more frequently (7%) or at an interval not listed on the survey (6%). Frequency of visits in these patients was related to new implantation ($n = 11$), coming in as-needed, depending on circumstances or when called ($n = 4$), or coming in every 2 years or more ($n = 8$).

A large proportion of all CIED respondents never felt nervous about attending the clinic (68%). Cross-tabulations showed that more adults younger than age 70 years ($n = 276$) and women ($n = 144$) reported always or sometimes being nervous attending the device clinic more frequently compared with adults aged 70 years or older (Table 3; $P = 0.0004$) or men ($P = 0.018$). Patients with an ICD reported being sometimes or always nervous attending a device clinic more frequently (24%) compared with using remote monitoring (14%; $P = 0.006$). Almost 70% of respondents did not require assistance to attend a device clinic (68.2%), however, many patients reported that they always (22.5%) or sometimes (9.3%) required help to some degree.

Participants indicated a high level of satisfaction with their clinic visits ($n = 479$). Cross-tabulations showed that respondents aged ≥ 70 years ($n = 234$) and those who identified as being retired ($n = 357$) reported always being satisfied with device clinic visits more often than younger respondents ($P < 0.0001$) and those still in the workforce ($P = 0.046$).

Suggestions for how device clinic visits could be improved were on the basis of logistics of the visit (eg, parking, location convenience, shorter wait times), coordination of care (eg, appointment coordination, advance notice, less frequent visits, cell phone-based remote monitoring), and information needs (eg, more opportunity for discussion/questions, cardiologist present).

Cost to attend clinic. Patients generally reported no cost-related issues that interfered with device follow-up; however, a small proportion ($n = 79$; 15.6%) did note that they have cost-related issues related to travel or lost wages. Cross-tabulations showed that patients younger than age 70 years vs older patients (19% vs 11%; $P = 0.01$), and those who live > 50 km away from their device clinic vs those who live closer to the clinic (26% vs 7%; $P < 0.0001$) more frequently reported cost issues that interfered with device follow-up. No differences were shown related to retirement status, sex, or ICD patient shock history.

Device effect on health behaviour. More than half of the survey participants ($n = 276$) reported that implantation of their device did not change the way they care for themselves. Participants who elaborated on reported changes in how they care for themselves noted being more health conscious ($n = 59$), making lifestyle modifications ($n = 27$), increases ($n = 18$) or decreases ($n = 27$) in physical activity, smoking cessation ($n = 4$), modified activities of daily living ($n = 15$), or psychological changes ($n = 13$). Cross-tabulations showed patients with ICDs who were followed remotely more frequently reported changes to self-care (47%) compared with ICD patients who attended clinic (34%; $P = 0.031$). No differences were shown related to age, retirement status, sex, ICD shock history, or distance from device clinic.

Remote monitoring experience and knowledge. Patients believed remote monitoring is helpful ($n = 221$; 89.8%). Less than 60% knew how to recognize that an alert has been triggered on their device, yet 65% ($n = 164$) knew what to do when they receive an alert. Survey respondents knew what to do when they receive a shock ($n = 191$; 75.8%). Most of the

participants believed it was very important to receive a phone call from their device clinic after a remote transmission was received (91%).

Attitudes toward exclusive remote patient management.

When asked about their comfort level with not having their devices checked in a hospital, participants indicated their preference to go to the clinic. Almost half ($n = 238$; 47.0%) indicated they would not feel secure with device checks exclusively done out of the hospital and another 20% were unsure ($n = 101$). Six participants liked the human interaction and the ability to ask questions during clinic visits, and one noted that the same specialists should be in charge of remote monitoring as in the in-clinic visits. There was interest in remote monitoring, with 2 respondents requesting more information on remote monitoring in general, 1 for remote monitoring via cell phone, and another 8 individuals expressing interest in remote monitoring because of the travel difficulties. Cross-tabulations showed patients younger than 70 years reported feeling secure with not having to go to the hospital to have their device checked (47%) more often than those aged 70 years or older (36%; $P = 0.023$). No differences were shown related to retirement status, sex, ICD shock history, distance from device clinic, or in ICD current follow-up.

There were no differences noted when cross-tabulation results for respondents in Nova Scotia were compared with those in other provinces ([Supplemental Tables S3 and S4](#)).

Interviews with key informants

Results from interviews with key informants are provided in [Supplemental Appendix S3](#) and participant characteristics are detailed in [Supplemental Table S5](#).

Discussion

To our knowledge, this is the first study to document patient and device clinic experience with remote monitoring from a Canadian perspective. We showed that CIED patients and device clinics perceive remote monitoring as safe, beneficial, and cost-saving. The current model of CIED care was shown to be heterogeneous and inconsistent approaches to the use of remote monitoring was shown in the clinics surveyed. The surveys highlighted that there are a number of areas where additional attention to standardization of care and directed resource allocation in the form of time, personnel, and reimbursement for services is warranted. We have highlighted a number of factors relevant to accessibility, resources, education, usability, and the practical day-to-day challenges of remote CIED follow-up for patients and the device clinics who manage them.

In our study, we showed that remote monitoring was used at least partially in all of the participating clinics, however, the use of this service model was disparate and variable, and inconsistent and/or limited funding policies across jurisdictions for in-clinic and remote visits are a real barrier to universal adoption. There are different organizational and jurisdictional funding models used in Canada and reimbursement requirements might influence factors such as whether a physician is present or not during the visit, or

individual follow-up with patients after remote visits. Current reimbursement models will likely threaten the sustainability of current models of care in device clinics as they increasingly accommodate more CIED patients remotely. Because very few clinics provided detail in the current survey, it is unclear how reimbursement policy more specifically acts as barrier to use, compliance, or enrollment at device clinics in Canada. Further qualitative and policy exploration is warranted. Unfortunately, there are no current data to understand how these variations might contribute to differential outcomes for patients or for the health system.

To our knowledge, there are limited guidelines that provide best practice guidance for implementation, quality of care, or management of the pragmatic day-to-day aspects of remote monitoring for CIEDs.^{3,11,14} As such, device clinics set-up, optimized, and resourced for in-person visits must translate available evidence into local clinical care settings and adequately resource patient education, data collection and management, and technology processes. This, coupled with the noted gaps and inconsistencies in reimbursement for remote follow-up, show that there is room for improvement.

We found that other barriers to remote monitoring might differ for patients according to device type, because of different patient characteristics and risk profiles, available technology, and the type or volume of transmissions. There is inherent heterogeneity in the device clinics, which translates to differences in access to care for patients. The location of clinics affects the burden of travel for all CIED recipients. This might contribute to certain subsets of patients continuing to choose in-clinic visits over remote follow-up. However, pacemaker patients might have less access to remote monitoring services because of a number of factors, including a lack of guidelines supporting remote follow-up for pacemakers and the need to prioritize high-risk ICD patients when resources are limited. The age of CIED patients might be a key variable across the barriers identified and likely influences remote monitoring uptake, compliance, and satisfaction. Younger CIED recipients might be more willing to consider remote models of care, whereas adults older than age 70 years might be more reluctant. In a 2017 survey of Canadian CIED patients who refused remote follow-up, fear of technology was rarely mentioned by the elderly patients, but loss of human contact was a principal concern.¹⁵ Similar concerns were also reported previously outside of the Canadian context.^{11,16}

This study has important implications for the future of remote monitoring for CIED patients. Our findings emphasize those from existing studies that the current model of follow-up care is associated with high levels of patient satisfaction because of alleviation of the travel and cost burden to patients living in rural or geographically remote areas.^{17,18} Similar survey data from Europe showed that reimbursement is a key barrier in other jurisdictions.¹⁹ Patients' desire for additional individual follow-up is an aspect that deserves further attention, and additional research is warranted to elucidate the characteristics of patients more likely to be accepting of remote-only CIED follow-up. Limitations in resources, communications technology, and inconsistencies in processes and reimbursement might pose barriers to implementing patient-requested program improvement measures, or to more universal adoption, as is

Table 3. Cross-tabulation results for patient survey.

	Are there any cost issues that interfere with your device follow-up?		Does attending the device clinic make you nervous?				Are you satisfied with your device clinic visits?				Does having this device change the way that you care for yourself?		Would you feel secure if you did not have to go to the hospital to have your device checked?	
	Yes	<i>P</i>	Always	Sometimes	Never	<i>P</i>	Always	Sometimes	Never	<i>P</i>	Yes	<i>P</i>	Yes	<i>P</i>
Whole cohort (N = 512)														
Age														
< 70 (n = 276)	52 (19.0)	0.011*	15 (5.5)	46 (16.7)	214 (77.8)	0.0004*	249 (90.2)	23 (8.3)	4 (1.5)	< 0.0001*	106 (42.4)	0.4	103 (46.6)	0.023*
70 or older (n = 234)	25 (10.8)		4 (1.7)	20 (8.7)	207 (89.6)		231 (98.7)	3 (1.3)	0 (0)		84 (38.5)		66 (35.5)	
Retirement status														
Not retired (n = 153)	24 (15.8)	0.82	7 (4.6)	24 (15.8)	121 (79.6)	0.18	138 (90.2)	14 (9.2)	1 (0.7)	0.046*	62 (45.6)	0.17	58 (47.9)	0.068
Retired (n = 357)	53 (15.0)		12 (3.4)	42 (11.9)	299 (84.7)		341 (95.8)	12 (3.4)	3 (0.8)		128 (38.7)		108 (38.2)	
Sex														
Male (n = 369)	61 (16.7)	0.25	11 (3.0)	41 (11.2)	313 (85.8)	0.018*	350 (94.9)	16 (4.3)	3 (0.8)	0.38	133 (39.1)	0.32	129 (43.1)	0.27
Female (n = 144)	18 (12.6)		8 (5.6)	25 (17.5)	110 (76.9)		132 (92.3)	10 (7.0)	1 (0.7)		57 (44.2)		40 (37.0)	
Distance to clinic														
Within 50 km (n = 280)	19 (6.8)	< 0.0001*	10 (3.6)	37 (13.3)	232 (83.2)	0.99	263 (93.9)	16 (5.7)	1 (0.4)	0.84	94 (36.7)	0.05	88 (40.9)	0.73
50 km or more (n = 231)	60 (26.2)		9 (3.9)	29 (12.6)	192 (83.5)		218 (94.4)	10 (4.3)	3 (1.3)		96 (45.5)		81 (42.6)	
ICD only (n = 371)														
Shock history														
No previous shock (n = 259)	50 (19.5)	0.46	11 (4.3)	30 (11.7)	215 (84.0)	0.81	243 (94.2)	13 (5.0)	2 (0.8)	0.63	95 (40.4)	0.23	94 (44.6)	0.25
Previous shock (n = 112)	18 (16.2)		2 (1.8)	20 (18.0)	89 (80.2)		102 (91.9)	9 (8.1)	0 (0)		48 (47.5)		34 (37.4)	
Device followed														
Attend clinic (n = 119)	19 (16.2)	0.45	8 (6.9)	20 (17.2)	88 (75.9)	0.006*	110 (94)	6 (5.1)	1 (0.9)	0.92	36 (34.0)	0.031	41 (46.1)	0.4
Remotely (n = 252)	49 (19.5)		5 (2.0)	30 (12.0)	216 (86.1)		235 (93.3)	16 (6.4)	1 (0.4)		107 (46.5)		87 (40.9)	

Data are presented as n (%) except where otherwise specified.

ICD, implantable cardioverter defibrillator.

*Statistically significant ($P < 0.05$).

also evidenced outside Canada.¹⁹ Lack of a unified, process-specific and guideline-supported approach to in-clinic follow-up after CIED implantation acts as a barrier to the development of unified approaches to remote monitoring, and it is unclear which facets of the reported remote follow-up are attributable to preference or necessity in the local clinic context.

Study limitations

This survey applies to major urban health centres across Canada, and patients surveyed were predominantly living in Nova Scotia. We were limited in the extent to which we could explore differences in participant demographic characteristics between Nova Scotia and other provinces. The power to detect more specific differences is lost because of the small numbers for the non-Nova Scotia group, and as such we cannot rule out the possibility of selection bias. This survey likely under-represents extremely rural or remote patients, as well as Indigenous populations. Certain geographic areas of Canada might also be under-represented. Because no information was collected on race or cultural variables, the extent of this under-representation is unknown. Because the province where a large proportion of the survey responses were collected is > 50% rural, it is unlikely that rural populations are under-represented. Although many of the patients who responded reside in rural areas, the experiences of the surveyed population might not represent the experiences of patients living in other areas of the country.

The number of patient survey respondents is relatively limited. The characteristics of respondents in the 5 provinces surveyed might differ from patients in other regions of Canada.

The survey approach using convenience sampling might limit the generalizability of the findings and our results should be interpreted with this limitation in mind. Despite this, we believe we have collected valuable and insightful information on CIED patients in Canada that can inform future research directions and priorities related to remote patient management.

The scope of the patient surveys was limited and did not take certain important patient characteristics into consideration, such as socioeconomic status or health status. Limited free-text comments from respondents did not permit for a fulsome understanding of some of the issues raised and this made it difficult to contextualize results. Resource limitations at the time of the patient survey prevented more in-depth follow-up using interviews or focus groups. There were a limited number of respondents with CRT devices, and ICDs and pacemakers were more often addressed in survey comments and discussed by key informants. Although the surveys and supplemental key informant interviews were conducted in 2015 and 2016, the responses are still considered to represent current attitudes, and might actually be of increased relevance because of the current health care limitations as patients and device clinics navigate the global COVID-19 pandemic. Changes to reimbursement for remote or virtual appointments for CIED patients have not been comprehensively documented across Canada, and it is unclear if any emergency authorizations will be maintained as health care facilities resume in-person visits as part of usual care.

The identified barriers to remote monitoring in Canada were not mapped directly to behavioural change techniques, which could be used to target actionable strategies to promote universal adoption and sustainability.¹⁴ Ongoing work will focus on additional quantitative and qualitative research in this area and concentrate on noted barriers in greater depth, and across a greater variety of contexts and settings. As institutional response to COVID-19 across Canada has resulted in physical distancing protocols in the hospitals, device clinics have responded by increasing remote follow-up. It is necessary to assess how changes in the health care landscape due to COVID-19 have affected CIED follow-up in Canada, for patients and device clinics, and to explore whether changes are temporary or permanent.

Conclusions

The current global pandemic related to COVID-19 has highlighted the importance of remote care. This survey showed that the lack of a unified, process-specific, and guideline-supported approach to follow-up after CIED implantation and inconsistent funding policies across jurisdictions for in-clinic and remote visits are major barriers to the use of remote patient management strategies in Canada. To incentivize remote models of care for patients with CIEDs, strategies to improve access and use across all indicated patient groups should be considered, and improvements made to the resources available to support patients and device clinics. Efforts to increase use of, or expand, remote follow-up need to take these barriers into consideration, as well as to recognize that some identified barriers might vary as a function of clinical or sociodemographic characteristics.

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Supplementary Material

To access the supplementary material accompanying this article, visit *CJC Open* at <https://www.cjcopen.ca/> and at <https://doi.org/10.1016/j.cjco.2020.11.010>.