INTRODUCTION

The Canadian Frostbite Collaborative project is exploring frostbite patient care needs and current practices in Canada to inform the development of a Canadian frostbite care network (CFCN) as a national quality improvement initiative.

METHODS

Using a quantitative and qualitative approach, this study aimed to define the landscape of current frostbite practices, challenges, and interest in future work.

RESULTS

Current frostbite care practices were initially assessed through semistructured phone interviews of Canadian healthcare providers. Canadian healthcare providers managing frostbite in a range of health disciplines and contexts then participated in focus group sessions discussing the potential roles and opportunities as well as potential challenges in developing a CFCN. Roles and opportunities for a network in advancing frostbite care included facilitating research, educating stakeholders, facilitating collaboration, standardizing care, and advocating for frostbite care. Challenges identified in frostbite care and network development included managing resources, navigating the Canadian healthcare system, overcoming low numbers, and communicating with policymakers and frontline providers.

CONCLUSIONS

Formalizing a CFCN may provide important opportunities and support in overcoming critical barriers to providing high-quality frostbite care across Canada.

Keywords: prevention, patient outcomes, protocol, collaborative research, frozen tissue
The effects of frostbite are exaggerated by alcohol/substance use, tobacco smoking, patient comorbidities, mental illness, use of neuroleptic drugs, previous cold injury, peripheral vascular disease, and neuropathy. Approximately 90% of frostbite injuries occur on the hands, feet, or face, highlighting the potential for significant functional implications, particularly in the setting of amputation.

The main principles of frostbite treatment are rapid rewarming in hot water, pain management, and prevention of refreezing. Multiple pharmacologic treatment adjuncts have been identified as potentially beneficial in treating frostbite pathophysiology. These include anti-inflammatory agents, such as ibuprofen and acetylsalicylic acid (ASA); vasodilators, such as iloprost; thrombolytics, such as recombinant tissue plasminogen activator; and the use of hyperbaric oxygen therapy. While treatment protocols for managing frostbite have been suggested, evaluation of patient outcomes across institutions is challenging because of low patient numbers and diversity in reporting and patient presentation. These limitations are well recognized and complicated by demographic/geographic factors that may delay initial treatment and make frostbite difficult to study effectively. As a result, the management of frostbite is currently quite variable. Available data highlight the need for early intervention by multidisciplinary teams with expertise in the area, including consideration of using a teleconference model. While there are numerous protocols in the literature, there is no clear consensus. The Wilderness Medical Society guidelines provide a clear description of the levels of evidence for many treatment modalities. While case evidence for advanced therapies, such as thrombolytics and vasodilators, continues to increase, it often requires consensus, data, and collaboration about how to study optimal management strategies.

Canada is well positioned to be a leader in the treatment of frostbite due to its geographic location. However, studies to date are restricted by small sample sizes, retrospective reviews, case studies, and single-center studies, further compounded by variability in transfer time for patients to receive treatment. The transferability of developed protocols is limited due to lack of clear evidence–based treatments, faculty expertise, availability of medications and equipment, limited overall patient numbers, and equivalency of frostbite severity. Increased participation in extreme adventure sports combined with the growing epidemic of homelessness will heighten frostbite presentation in both large urban centers and resource-limited rural centers. There is an opportunity to improve patient care through the investigation and identification of optimal treatment pathways and practices.

This study aimed to identify and describe current frostbite care practices in both rural and community hospitals and tertiary care burn centers across Canada. The study also aimed to investigate interest in and potential roles of a collaborative Canadian frostbite care network (CFCN) to improve patient outcomes and standardization of frostbite care.

**Methods**

We have followed the Standards for reporting qualitative research (SRQR) and Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) cohort guidelines, including information in the manuscript on background, survey development, methodology (including sampling rationale), participant description, analytic approach, and discussion (including limitations). We have utilized guidelines for reporting observational studies from the STROBE statement for phone survey analysis and followed the SRQR checklist during manuscript preparation.

This study was reviewed and approved by the Laurentian University research ethics board, file number 6020977. In order to answer the research questions, both quantitative (survey methods) and qualitative methodologies (focus group methods) were used. Because of the low number of frostbite presentations, this study used a qualitative approach to target populations with an interest in or experience with frostbite treatment. Incorporating both quantitative and qualitative methods allows enhanced richness of result data and increases the validity and reliability of results.

**PHONE SURVEYS**

Semistructured interviews were conducted by telephone to collect descriptive data regarding current frostbite care practices and the use of protocols or order sets. Participants were emailed the consent form and survey prior to their interview. Consent was verbally confirmed with each participant prior to data collection. The survey included 20 closed-ended questions, several of which invited comments, which were not formally analyzed for thematic interpretation (Appendix A). Survey questions focused on institution demographics, treatments used, the incorporation of frostbite protocols, frostbite grading, technology, access to expertise, barriers to care, and desire to participate in a collaborative frostbite network.
Survey questions were initially developed by the study lead investigator (CC) and vetted through a modified Delphi design with a multidisciplinary national team prior to study commencement. Participation was sought using purposeful sampling, including all Canadian burn centers, as they would be the regional referral sites for frostbite care. Also included were individuals who had previously requested support from the study investigators (AJP or JG) in frostbite case management. Participation was expanded through snowball sampling of interviewees. Phone surveys were conducted by research team members.

FOCUS GROUPS

Focus groups involved in-depth group interviews with targeted participants to identify perceived needs in the management of frostbite. Focus group participants were invited to attend based on their expressed interest in frostbite treatment and were not required to have experience or be experts in managing frostbite. This methodology was chosen as it has been found to be useful for involving care management practitioners with strategy development techniques.

Focus group data were collected in February 2022 via Zoom. The focus group was moderated by a research team member (JS-T) trained in qualitative research methods, with assistance from the entire research group. Initially, in a large group, all participants were introduced to the moderator, the research group, and planned topics to be covered, and consent was confirmed. Participants were then randomly divided into 4 smaller focus groups of 8 to 12 participants (using Zoom breakout rooms), each group with a moderator and note taker.

Moderators guided each focus group using a semi-structured script while the assistant made field notes and summarized major discussion points within the web-based chat feature, giving participants an opportunity to clarify anything they felt was missing or misunderstood by the research team. The focus group guide was initially developed through comments collected during the phone interviews. It was then revised for appropriateness in an iterative process, which is standard for qualitative procedures.

Focus group participants were asked to elaborate on topics identified in the semistructured phone interviews, including the roles of a CFCN and how those roles should be prioritized, the challenges and opportunities of implementing a CFCN, and suggestions about research questions in frostbite care that could be facilitated through a CFCN. After each of these topics, the participants were given time to ask questions and voice their opinions. The focus group sessions lasted approximately 1 h and were audio recorded and then transcribed for analyses.

Analysis

Triangulation was used in this study (using phone surveys and focus groups) to enhance the richness of the data and increase the validity and reliability of results.

PHONE SURVEYS

Quantitative responses were collated and analyzed using Microsoft Excel (2022). Data analyses included descriptive statistics. Missing data were not imputed. Comments gathered from participants were transcribed, and the most common responses were used to inform the focus groups’ direction.

FOCUS GROUPS

Focus group qualitative content was analyzed using Braun and Clarke’s (2006) 6-step thematic analysis. Four authors independently analyzed transcript data from 3 of 7 focus group transcripts using NVivo software to inductively identify preliminary codes. They then met to discuss emerging codes and agree upon a code book. All focus group transcripts were then analyzed by 2 reviewers using the developed codes to iteratively finalize themes. Researchers performing coding communicated as needed during final coding to discuss any new codes that emerged. Saturation of data was ensured during the coding process. The authors focused on establishing trustworthiness at each phase of the thematic analysis. Appendix B highlights the components of trustworthiness of qualitative data.

Results

PHONE SURVEYS

Phone surveys were primarily conducted between March and August of 2021, with 2 surveys taking place in early 2022 (Appendix A). In total, 21 healthcare professionals from throughout Canada participated, with representation from all provinces and territories except Prince Edward Island, New Brunswick, and Newfoundland and Labrador. Participants included 12 physicians, 1 nurse practitioner, and 8 hospital pharmacists. There were 14 participants from tertiary care facilities and 7 from rural
or community hospitals. All specialty burn units in Canada were invited to participate in this survey, and 11 of them contributed. The participants’ precise specialty/area of practice, geographic location, and employment institution are not detailed to preserve participants’ anonymity.

Thirty percent of respondents indicated that their facility treats <5 frostbite cases, while 40% routinely see >10 cases over a 5-y period. Equal numbers of facilities reported having a frostbite order set (48%), and 57% use a formal grading system (most often the Cauchy system). Only 20% of respondents indicated using nuclear imaging or angiography.

Only 38% of respondents indicated that their facility has a treatment protocol for frostbite, 75% of whom use the Whitehorse protocol. Barriers for treatment included obtaining and administering iloprost, which requires special authorization from Health Canada. Low patient volume and lack of experience/expertise and specific resources were also reported.

Rapid rewarming protocols were used by 53% of respondents, with a median temperature of 39°C, ranging from 37 to 40°C. Nonsteroidal anti-inflammatory drugs were used by 95% of facilities surveyed, most commonly ibuprofen (90%), followed by ASA and ketorolac. Other forms of pain management were used by 86% of facilities, most frequently opioids (95%). Topical medications were used by 81%, most frequently Aloe vera (58%), followed by silver-based products (20%). Prophylactic antibiotics were used in only 14% of responding facilities.

Seventy-one percent of respondents indicated that their facility used either vasodilators or thrombolytic agents, with iloprost reported slightly more often than alteplase (52% vs 43%, respectively). Anticoagulants were used in combination with these medications in 47% of these facilities. While 38% of respondents indicated having access to hyperbaric oxygen, many commented that it was not regularly used in frostbite care.

With respect to access to local expertise in frostbite care, respondents confirmed that 50% had access to (or were themselves) local experts, while 71% had access to expertise via email, text, or telephone. Respondents almost unanimously agreed that there is a need for improvement in frostbite care (94%), and 100% of respondents supported standardization of treatment protocols. A significant number of respondents (90%) indicated that they were willing to participate in a national collaborative frostbite care network, highlighting the need for research on the most effective protocols, sharing of best practices, and patient care.

Participants unanimously indicated that standardization of evidence-based protocols would significantly improve treatment of patients with frostbite, and >90% were interested in participating in a CFCN.

FOCUS GROUPS

Forty-three participants took part in the virtual focus group and were randomly divided into 1 of 4 smaller groups after introduction, consent was obtained, and preliminary information was shared. Participants varied by stakeholder group, sex, and location of residence across Canada. Participants were asked their employment details, but not all chose to disclose this information. Responses of the remaining participants are not reported to avoid inadvertent identification of participants. See Tables 1 and 2 for details on stakeholder groups. Focus group discussion focused on the roles, priorities, challenges, and opportunities of a CFCN (see Table 3 for focus group script).

Roles and Priorities of a CFCN

After discussing the possible roles and priorities of a CFCN, 5 main categories emerged. Top roles and priorities included 1) facilitating research, 2) educating stakeholders, 3) facilitating collaboration, 4) optimizing frostbite care, and 5) advocating for frostbite care in Canada. See Appendices C and D for complete quotations for each category.

FACILITATING RESEARCH

Participants felt that a network could facilitate conducting research and data collection. Primary proposed roles of this network included developing specific research questions, facilitating multicenter studies, and sharing data through a central registry.

“I think we have an advantage if we have a network that can study protocols...across multicenters, and have larger numbers, and maybe try to hammer down at least what is our current best practice, because I think there is no good standard right now that is across the board as the all-encompassing standard to follow.” (Transcript 2)

Table 1. Respondents: phone surveys

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Number (total)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician</td>
<td>10</td>
<td>55.6</td>
</tr>
<tr>
<td>Hospital pharmacist</td>
<td>8</td>
<td>44.4</td>
</tr>
</tbody>
</table>

Klammer et al
EDUCATING STAKEHOLDERS

Educating stakeholders was another commonly cited role for a CFCN. Separate discussions emerged on the need to educate healthcare professionals and the public. The primary educational needs expressed for health professionals were related to assessment and management, whereas prevention was the primary educational need expressed for public stakeholders.

“Finding a way to get everybody aware of all these new protocols, and all the advances in this field, and probably afterwards getting more education for nurses, and primary care.” (Transcript 4)

FACILITATING COLLABORATION

Another important role that emerged during focus group discussions was the ability of a network to facilitate collaboration. Specifically, facilitating interdisciplinary and national or multicenter collaborations was described

OPTIMIZING FROSTBITE CARE

The need for a network to optimize care was a central theme in many discussions. The method of optimizing care came forward when participants described CFCN’s potential role in developing protocols and supporting protocol implementation. Participants described both roles as being necessary at all stages of the treatment trajectory from prehospital to inpatient and outpatient care, inclusive of quality improvement to optimize patient care.

“A protocol that has a few different streams that people can provide treatment through. So, for example, if you are in an institution that doesn’t have iloprost or TPA yet, or maybe you are just in a very small rural community health center, what you can do to provide optimal care with limited resources.” (Transcript 5)

ADVOCATING FOR FROSTBITE CARE IN CANADA

Finally, participants described advocacy as an important role of a CFCN. This included the need to advocate for resources related to frostbite assessment and management, such as imaging, medications, and clinical expertise. Participants commented that advocacy should occur through communication with stakeholders and by demonstrating leadership in frostbite care.

“...let us create a network, create the governance, create some guidelines, communications, a website...[we need to get] a bit more public...a bit more into their face, and then we start presenting in different areas, so at any national meetings, we go there...And, then we need to start networking and going and beating our drums to other societies, or anywhere else where we think that it may have an impact...and we make alliances from there.” (Transcript 3)
Challenges of Implementing a CFCN

When considering the challenges of implementing a CFCN, 4 main themes emerged. These included 1) managing resources, 2) navigating the Canadian healthcare system, 3) overcoming low case volumes, and 4) communicating effectively with stakeholders. See Appendix B for example quotes for each theme.

MANAGING RESOURCES

Managing resources was frequently reported as a challenge in implementing a CFCN. This was primarily described in relation to time constraints and human resources, in addition to logistical planning for a platform, technology, database creation, and overall funding. The need for identified champions in the field was of particular importance.

“Certainly...getting a local champion is always a challenge, especially in places where there is quite a lot of turnover and there is so much going on. Everyone is so short staffed, so finding a local champion of each disease state is certainly a challenge locally.” (Transcript 4)

NAVIGATING THE CANADIAN HEALTHCARE SYSTEM

Participants described navigating the Canadian healthcare system as a challenge to the implementation of a CFCN. Differences in healthcare across provincial and territorial boundaries and regional variation, such as urban vs rural settings, need to be considered for a meaningful national collaboration.

“...Some of the challenges in Canada are that we talk about equal access to healthcare, but it isn’t equal access to healthcare if you are in a remote area that doesn’t have some of the [iloprost], or the TPA even, or access to some of the warming. So, I think that is a challenge that we do need to take into consideration for implementing the network, is the different levels of access to the different resources, and maybe an understanding of how to implement some of these suggestions, or some of these opportunities as we go through that.” (Transcript 1)

OVERCOMING LOW CASE VOLUMES

The low number of frostbite cases and resulting reduced exposure and expertise in frostbite may present a challenge when implementing a successful CFCN.

“The other thing is I think with frostbite, it is temporary, right, it is 5 months of the year, not the other 6...I think the challenge is one it is seasonal...We don’t have a story that we can say that is compelling and that politicians up in the parliament take notice of. And, it is low incidence so people

when they put in their list of 100 things, I don’t think it will come in the top unless we make noise of it.” (Transcript 3)

COMMUNICATING EFFECTIVELY WITH STAKEHOLDERS

Finally, effective communication was said to be a challenge facing a CFCN. This came forward when discussing the need to engage policymakers and frontline care providers. While local practitioners may see the need for these resources, there is a requirement for provincial and national support to ensure that meaningful change can occur.

“Ultimately, the patient presents to the emergency room, and if the person who sees them, or the family doctor, doesn’t recognize that, A: this has a specific way of caring for it, and there is expertise in our center for this, there are policies, there is a care network around it, we may never be involved with that patient’s care, even if we are in town working in a nearby location. I feel like there is a lot of education that would be needed... creating the network and [getting] people who are aware of the network, whether or not they are involved intimately with the network...these are 2 interdependent challenges.” (Transcript 3)

Interpretation

Quantitative data collected through phone surveys confirmed that frostbite treatment across healthcare centers within Canada varies significantly with respect to available resources, treatments, and expertise. While many institutions make every effort to optimize patient outcomes, lack of standardized protocols, evidence-based guidelines, and resources result in inconsistency in patient care.

Perhaps more important, respondents from both the phone survey and focus group confirmed that there is significant interest, commitment, and need for scientific data collection and analyses to establish optimal protocols for patients in rural and urban settings. It has been noted in publications prior to this study and from respondents in this study that current evidence is weak due to low patient numbers and predominance of retrospective single-center studies.

While the data collected offer a “snapshot” of current frostbite care throughout almost all of Canada, they do not represent all healthcare centers and were potentially biased by including participants with interest in frostbite care.

What was consistently reported from both the semi-structured interviews and the focus groups is the need for a CFCN to facilitate research, educate stakeholders, facilitate collaboration, optimize frostbite care, and advocate for frostbite care in Canada.
Creating this CFCN would help define and address existing gaps in frostbite literature to improve frostbite care and outcomes. A CFCN could provide a critical opportunity to better understand the care needs of patients and variability in frostbite care through collection and analysis of data, treatment pathways, and patient outcomes across Canada. A critical goal of this network would also be to support development of evidence-based best practices to optimize care. A CFCN could enable data collection across multiple centers to increase patient population samples and support advocacy for improving frostbite care in Canada. The presentation of similar infrequent conditions that occur across vast geographic areas would likely benefit from discussion among interested clinicians and researchers to create a registry that can be used to develop, standardize, and optimize protocols and treatments for frostbite.

Challenges in creating a CFCN were noted and primarily involve human resources, navigating the various provincial healthcare systems, overcoming low case numbers, and communication. While these challenges exist, participants demonstrated significant interest and stressed the need for improved patient outcomes through clear and consistent treatment pathways.

Future directions include developing a platform for the CFCN and beginning to implement the roles and priorities identified in this study. Identifying local champions and fostering leadership in frostbite care research and practice are also priorities for the CFCN to optimize its potential. By doing so, multicenter research projects on frostbite presentation and outcomes across regions and demographics can be supported while laying the groundwork for clinical trials and development of evidence-based protocols.

Limitations

To preserve participant anonymity, granular demographic information on participant location and occupation was not reported for either the phone survey or focus groups. This limited our ability to ascertain participants’ level of experience with frostbite and their understanding of current management practices. Potential phone survey participants were identified by contacting Canadian burn centers, individuals who had previously requested help with frostbite management, and snowball sampling from interviewees. This may have resulted in selection bias as all participants would have had some interest in frostbite management. It may also have resulted in sampling bias as it does not reflect the experiences of physicians who may treat frostbite but who are unaffiliated with burn centers and have not discussed management with others, for example, rural or remote physicians unaffiliated with academic centers.

Conclusion

Frostbite care varies across Canadian centers due to availability of resources, expertise, and low patient numbers. The participants in this study expressed a need for standardized and evidence-based protocols that can be used within an institution’s available resources to provide optimal patient care. There is a clear need and keen interest in collaborative research, education, and communication among Canadian healthcare providers to facilitate quality improvement in the future of frostbite care.

Authors Contributions: All authors have contributed equally to each phase of the study, critically reviewed, and approved the manuscript.

Financial/Material Support: Funding for this study was provided by a Clinical Innovation and Opportunities Grant from the Northern Ontario Academic Medicine Association.

Disclosures: None.

Supplemental Material(s)

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.wem.2023.06.001

References