A Foot Health Pathway for People Living with Diabetes: Integrating a Population Health Approach

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Current Issues with Diabetic Foot Disease: The Disease Model

Complications from diabetes result in significant challenges for individuals, families and healthcare systems.^{1,2} Those living with diabetes are more likely to be hospitalized, live with cardiovascular and renal complications and experience diabetic foot ulcers (DFUs), the leading cause of non-traumatic lower limb amputation.³ People at risk for or living with diabetic foot disease report that the fear of amputation is more significant to them than the fear of death.⁴ The lifetime risk of a diabetic foot ulcer is 19-34%, with a recurrence rate of 40% within a year.⁵ The good news is there are successful evidence-based solutions to prevent four out of five amputations.⁶ The Foot Health Pathway presented here-which is based on an approach that has been successfully implemented in other countries-provides a framework that could be used for optimized care delivery in Canada.

The development of pre-ulcerative lesions and DFUs is a result of well-defined pathophysiologic changes that involve one or more of the following (see Figure 1):

- Neuropathy (loss of protective sensation, leading to injury)
- Foot deformity (as a result of neuropathy, leading to pressure points)
- Peripheral arterial disease (PAD) (compromised blood supply, leading to poor healing outcomes and increased risk for ulcers)

Major foot amputations are on the increase. A recent Canadian study demonstrated the overall rate of any (major or minor) amputation initially declined from a quarterly rate of 9.88 per 100,000 individuals to 8.62 between 2005 and 2010 but increased to 10 per 100,000 individuals by 2016.⁷

Diabetes foot health services in Canada are fragmented—a costly problem that deserves more attention.^{7,8} Funding is inconsistent and is based on treating problems, not preventing them. Funding is split between public and private payers Figure 1: The pathophysiological conditions required for the development of diabetic foot complications

The Foot Complications Equation



Note: The development of ulcerative DFU or pre-ulcerative lesions (e.g., callus) results from sequelae related to neuropathy. The three types of neuropathy are: **motor**, causing weakness of the small muscles, with resultant foot deformities and biomechanical imbalance; **autonomic**, leading to overly dry skin prone to breakdown; and **sensory**, causing loss of protective sensation. Foot deformities, along with minor trauma related to footwear or other mechanical causes, can precipitate injury to the tissues. Approximately 50% of patients with diabetes also have underlying arterial insufficiency.⁹ This will impact DFU formation and impair wound healing. Metabolic abnormalities related to diabetes will also impact wound healing and the risk for infection. This road to ulceration is also the path to prevention, as many of these issues can be recognized early and managed in the community.

with no co-ordination between the two. What is often missing for persons with diabetes in Canada is timely access to:

- Preventative foot care and screening programs as a part of a national strategy
- Early interventions based on risk
- Proper footwear and offloading devices funded by provincial/territorial health plans
- Access to and/or co-ordination among care providers and payors

In addition, people at risk may not receive enough education about how to care for their feet to prevent or manage foot complications.¹⁰ Such deficits can lead to complications that result in patient suffering and significant social and health-system costs.^{11,12}

Research has shown there is a significant economic burden associated with poor foot health, diabetic foot issues and amputations. Hopkins and colleagues reported that "the annual cost associated with DFU-related care was \$547.0 M, or \$21,371 annual cost per prevalent case."¹³ This is viewed as a fraction of the total impact to society and the economy—which also would include: intangibles such as pain and suffering, care provided by nonpaid care partners, loss of employment and related costs and impacts on family units.¹³ "Canada is not listed among the top 10 countries for the number of people with diabetes, but it is among the top 10 for diabetes-related health expenditures, with the cost estimated to be \$23 billion. This cost is projected to rise to almost \$30 billion in 2040."¹³

Diabetic foot hospitalization = A costly intervention

Did you know? A Toronto-based study found the cost for treating foot ulcers related to diabetes was almost \$23,000 per patient, compared to the cost of a stroke at about \$10,000 per patient.¹⁴

The Foot Health Pathway and the Population Health Model

The Foot Health Pathway takes a risk-based approach focused on patient outcomes, experiences and value-based care consistent with the population health principles outlined by the Institute for Healthcare Improvement (IHI).¹⁵ The aim of this approach is to prevent foot ulcerations, the devastation of amputations, and amputation-related deaths.

To develop the Foot Health Pathway for People Living with Diabetes, a group of Canadian stakeholders (experts and organizations) associated with Wounds Canada came together to develop a system-based guide based on the principles of the IHI's Quadruple Aim framework¹⁵ (see Figure 2). The aims are to:

- Enhance the patient experience
- Improve health outcomes
- Improve value to the health-care system
- Enhance the provider experience

Figure 2: The four components of the Institute for Healthcare Improvement's Quadruple Aim framework¹⁵



The resulting Foot Health Pathway outlines a prevention-based, holistic approach for people living with diabetes, *whether or not they have already developed diabetes-related foot complications* (see Figure 3). The Pathway consists of four domains, each organized around interventions that drive the most desirable outcomes for patients at different levels of risk.

With this approach the focus is on prevention, or "upstream" interventions (yellow and green domains) to prevent "downstream" complications (orange and red domains). While prevention of foot complications is key, it is also necessary to structure health-care systems for the delivery of timely care for persons who do develop a foot ulcer, Charcot deformity, acute critical ischemia or infection (red and orange domains).

Figure 3: The Foot Health Pathway for People Living with Diabetes



For a larger version, see Figure 4 on pages 22 and 23.

Upstream:

Upstream interventions are carried out by a team, including the patient and their families, that focus on the prevention of diabetes and diabetes-related foot complications in relation to social determinants of health, lifestyle engagement and self-management.¹⁶ This care takes place in the community.

Downstream:

Downstream interventions are activities that respond to existing diabetes-related foot complications.

Implementing the Foot Health Pathway

The risk-based Foot Health Pathway provides all stakeholders—including patients and families, health-care providers, administrators, policy makers and researchers—with a clear vision of how the population health approach can be delivered and evaluated at an individual, facility and systems level.

Assess risk

The first step is to identify persons with diabetes and establish their risk for foot complications. A plan of care, with interventions such as a schedule for foot screening at appropriate intervals, can then be implemented.⁹

Early intervention

A callus on a foot may seem like a minor issue; however, for a person with diabetes this represents a pre-ulcerative lesion and should have a defined path for timely evaluation and treatment. The onset of a DFU, a more serious issue, deserves immediate attention by a specialized care team to avoid complications.

Appropriate education

Education is included in all four domains, and it is incumbent on all health-care providers to engage the individual, family and others to become partners in care to identify foot and skin issues early and know where to access timely professional evaluation and intervention.

Individualized care plans

Each domain is organized to assist in identifying an individual's specific risk and then recommend

an appropriate care plan, using a holistic approach, complete with follow-up requirements. These requirements include the need to manage blood glucose and other diabetes-related targets such as cholesterol and blood pressure. Fortunately, care related to comorbidities is available through primary care, sub-specialties and patient self-management. The targets for optimal management of persons with diabetes are listed in Table 1.¹⁷

An Illogical Gap

Individuals with diabetes have ready access to preventative interventions and resources for other disease complications related to eye, cardiac and renal issues that help prevent blindness, heart disease and renal failure. It is necessary to complete their care by implementing risk-driven foot screening to prevent amputations.

A	A1C targets	 AIC ≤ 7% If on insulin or insulin secretagogue, assess for hypoglycemia and ensure driving safety 		
В	BP targets	BP < 130/80 mmHgIf on treatment, assess for risk of falls		
С	Cholesterol targets	• LDL-C < 2.0 mmol/L		
D	Drugs for CVD risk reduction	 ACEI/ARB (If CVD, age ≥ 55 with risk factors, OR diabetes complications) Statin (if CVD, age ≥ 40 for Type 2, OR diabetes complications) ASA (if CVD) SLGT2i/GLP1ra with demonstrated CV benefit (if have type 2 DM with CVD and A1C not at target) 		
E	Exercise goals and healthy eating	 150 minutes of moderate to vigorous aerobic activity per week and resistance exercises 2–3 times per week Follow healthy dietary pattern (e.g., Mediterranean diet, low glycemic index) 		
S	Screening for complications	 for Cardiac: ECG every 3–5 years if age > 40 OR diabetes complications Foot: Monofilament/Vibration yearly or more if abnormal Kidney: Test eGFR and ACR yearly, or more if abnormal Retinopathy: yearly dilated retinal exam 		
S	Smoking cessation	• If smoker: Ask permission to give advice, arrange therapy and provide support		
S	Self-management, stress, other barriers	 Set personalized goals Assess for stress, mental health and financial or other concerns that might be barriers to achieving goals 		

Table 1: ABCDESSS of Staying Healthy with Diabetes

Source: Diabetes Canada¹⁷

Green = Low Risk

- Person with diabetes and no history of diabetic foot disease or complications
- Goal: Promote foot health and prevent diabetic foot disease

An upstream, population health approach should be utilized to identify foot risk and then improve early detection, with the aim of preventing



diabetic foot complications.¹³ To this end, appropriate health policy should be in place to provide and promote foot screening for individuals with diabetes. Patients in the green domain are low risk, and the green domain is a considered a low-cost domain.

This foot health and prevention perspective requires a care approach that supports patient education and engagement in their own daily foot care activities.^{18,19} It also identifies diabetic foot problems (calluses, corns, ingrown toenails, fungal infections) and associated risk factors that can result in further complications and development of active pathologies, which would move the patient to the yellow domain, with different surveillance parameters.

Ideally, patients with diabetes who are defined as low risk (green domain) need to be screened annually as per Canadian guidelines.¹⁹

Location of care:

Care takes place at home and in the community in locations such as primary care offices/clinics and diabetes education centres. Depending on resources in communities there are many health providers that can screen and educate patients about the general principles of diabetic foot health.

Yellow = Moderate Risk

- Person with diabetes-related foot disease (neuropathy, PAD, deformity, plantar pressures)
- Goal: Prevent development of diabetes-related foot complications like DFUs before they become serious and/or urgent

Patients in the yellow domain are at higher risk for foot complications because they have identified risk factors; neuropathy and/or deformity and/or peripheral



arterial disease. Even though they may not have an ulcer, they will require more frequent screening and preventative foot care interventions to manage pathologies such as calluses, blisters and ingrown toenails. This is a critical time for preventative interventions, as the next step is a complication that moves the patient into the red domain. The screening interval in this domain is every 3–6 months depending on the identified risk.

Location of care:

Care for patients in the yellow domain remains in the community (primary care, preventative foot care clinics, diabetes education centres and pharmacies in some communities). It is essential that the screening clinician be able to manage the identified foot issue or refer to the appropriate care provider.

Note: Often, the offloading of pressure—which is key to managing calluses and other foot deformities—is required. It is a specialized skill most often provided by chiropody/podiatry and is needed at this crucial time to prevent additional, more serious, complications. Because of neuropathy, foot deformities change over time and require more frequent screening by a specialist. Footwear education, evaluation and adjustments are patient specific and must be ongoing. In Canada, funding for this specialized care would improve the system of health-care delivery so patients with diabetes could be better supported in the community.

Who and when? The Green and Yellow Domains

Patients and Care Partners

Individuals, their families and care partners are the first line of defence for preventing diabetes-related foot complications. Their individualized, risk-based plan of care should include:

- Access to education/information about their condition, risks, supports and resources
- Self-monitoring through daily foot inspections, basic foot nail and skin care
- Selection and use of appropriate footwear
- Identification of necessary contacts in the event of a concerning change

Each time individuals see their health providers, including their family physician, podiatrist, nurse practitioner or certified diabetes educator, they should ask or remind these health providers to assess and discuss their risk level for developing diabetes-related disease or complications and initiate interventions as necessary.

Screening, assessments and care planning should begin as soon as they are diagnosed with diabetes and continue throughout their lives.

The Clinical Team

According to the International Working Group on the Diabetic Foot, the health providers who should support individuals at the lower levels of risk include:⁹

- Primary care practitioners, diabetes educators, dietitians and pharmacists for Low Risk (Category 0)
- General practitioners, podiatrists, chiropodists, diabetes educators, dietitians, pedorthists and orthotists for Moderate Risk (Category 1)

Where this screening takes place is dependent on available resources across the country. Screening and primary care are the responsibility of providers such as family physicians, podiatrists/chiropodists, nurse practitioners, certified diabetes educators, dietitians and pharmacists. Some key points for them to consider include:

- At-risk patients should have foot exams scheduled according to their risk. A commonly use risk assessment tool is Inlow's 60-second Foot Screen
- Patients need to set realistic and practical goals to support a healthy lifestyle to reduce the risk of developing diabetes-related foot complications
- Socio-economic determinants of health that may be barriers for the patient should be investigated and addressed as part of any care plan²⁰
- Professional development for care partners/clinicians in the areas of skin and wound care should be supported, as rates of diabetes and diabetes-related foot complications are on the rise²⁴

Red Domain = Urgent Risk (Complications)

- Person with diabetes with active ulcer/ infection/active Charcot/critical ischemia
- Goal: Deliver timely care to address and minimize diabetes-related foot complications

Individuals who have an active foot ulcer, infection, Charcot neuro-osteoarthropathy, or critical limb-threatening ischemia represent an urgent issue. In any of these scenarios, the goal is to eliminate or minimize complications through timely access to specialized care.⁹



Persons with limb- or life-threatening complications need to involve an interprofessional team, ideally within 24 hours.^{21,22} In a country as large as Canada, this can be a challenge for some patients, particularly for those living in remote or rural communities. A potential solution involves increased educational programs for both clinicians and patients, as well as access to virtual wound care hubs.²³ Ideally, the need for this level of care can be reduced if the Pathway is implemented in all regions.

Location of care:

Depending on the urgency of the condition and availability of wound care services, initial care may take place in a hospital emergency department or a foot care centre in which multiple disciplines specializing in diabetic foot care are assembled. The team to manage these patients varies but often includes wound care nurses and physicians, a vascular surgeon, infectious disease specialists, endocrinologists and others related to specific patient comorbidities.^{24,25}

To address current gaps, policy makers, administrators and researchers should investigate the feasibility of establishing multidisciplinary virtual or physical limb preservation clinics across Canada. This approach, which has proven successful in other countries, is a well-established method to enhance support of limb preservation efforts based on what is known as the Toe and Flow model.^{26,27} The

Table 2: Three Levels of Limb Preservation Clinics

	Aims	Location	Team Members
Basic	Prevention and basic curative care	 Office, health centre, small regional hospital 	 Podiatrist, primary care practitioner, foot/wound care nurse
Intermediate	 Prevention and management Advanced assessment and diagnosis 	Hospital	• Podiatric surgeon, vascular surgeon, diabetologist, diabetes educator, wound care nurse
Advanced	 Prevention and curative care for complex cases Advancement of knowledge base Education 	• University hospital	 Podiatric surgeon, vascular surgeon, diabetes educator, orthopedic surgeon, orthotists, rehab therapist, psychologist, infectious disease specialist, diabetologist, wound care nurse

Adapted from Rogers and colleagues.27

presence of more of these clinics in Canada would facilitate the engagement of all stakeholders working together in all regions and better address patient risk factors, including social determinants of health. Table 2 illustrates the aims, location and personnel generally present at the different types of limb preservation clinics.

Orange Domain = Very High Risk

- Individuals with a history of an active foot ulcer, Charcot foot or critical ischemia
- Goal: Prevent recurrence of ulcer and other complications

After a DFU is closed, there is an estimated 40% recurrence rate within one year and almost 60% within three years.⁵ Once a foot ulcer has closed, the new tissue is only 75–85% as strong as the original.²⁸ These figures remind providers to consider individuals who have achieved wound closure as "living in



remission" rather than having a healed wound.²⁸

A gradual return to pre-ulcer level activities is recommended.^{29,30} Patient education should focus on sustaining engagement in diabetes and foot self-care and implementing strategies to maintain remission. Strategies should include screening every 1–3 months, offloading devices, appropriate footwear, daily foot exams, glycemic control and healthy nutrition.

Location of care:

Care for patients in the orange domain takes place at home, in a primary care setting and/or in a specialized foot care centre.

Policy Support for the Pathway

The Foot Health Pathway highlights upstream preventative care, timely detection and immediate intervention for pathology as well as the implementation of activities to prevent wound deterioration and recurrences. The following elements must be part of any successful Pathway implementation plan:

- A vision for health goals based on risks that support wellness, early intervention and timely access to appropriate care
- Policies to ensure and guide identification, screening and risk stratification for foot complications in all individuals living with diabetes
- Policies to guide policy makers, administrators and researchers on relevant outcomes measurement and data collection, analysis and dissemination
- Policies to support the implementation of prevention strategies

• A culture where the development and implementation of individualized, patient-driven care plans are the rule, not the exception

Evaluation of this approach should be done by audits of the services that have adopted the Quadruple Aim framework³¹ to inform ongoing quality improvement.

Who and when? The Red and Orange Domains

Patients and Care Partners

Patients in the red and orange domains should continue to perform the activities outlined for the green and yellow domains. In addition, they should receive:

- Regular updates about their health status
- Ongoing education about interventions, selfmanagement, how to identify emergencies and what to do in an emergency
- Support and encouragement to be involved in care planning and goal setting
- Emotional and spiritual support

The Clinical Team

Specialists are required to manage the emergencies of patients described in the red domain. The types of practitioners are outlined in Table 2.

Once the person is no longer facing an emergency, primary care providers are well positioned to screen and educate these patients, who are now in the orange domain. However, primary care providers do not generally have the expertise to manage offloading and footwear recommendations, and they should be made aware of the resources available in the community so they can direct patients appropriately and avoid delay in accessing the right specialist at the right time.²² Excellence in communication between specialists and primary care providers is essential for co-managing these patients, particularly in rural and remote areas. A co-ordinated, proactive approach incorporates crucial steps to prevent poor outcomes, including:

- Ongoing foot inspection
- Early detection
- Immediate action and intervention
- Excellent communication among patients, families and health providers
- · Early referrals to foot and/or wound care specialists
- Patient, family and other care partners' engagement in foot self-care

Requirements

Health systems implementing the Foot Health Pathway will be required to:

- Support preventative practices to reduce the incidence of DFUs and optimize access to preventative services
- Invest in primary care and community care to support diabetic foot screening and risk stratification
- Provide access to high-quality interprofessional wound care services
- Implement standardization in clinical practice and integrated referral protocols that are informed by the Quadruple Aim framework
- Align human resources for competency-based care delivery to optimize services
- Ensure services support timely and appropriate access to wound care services and enhance access to use of innovative health technology
- Support value-based and person-centred care delivery models
- Build mechanisms to effectively measure, monitor and evaluate processes and outcomes related to the prevention and management of foot complications
- Develop, implement and evaluate awareness strategies and campaigns informed by the best available research.¹⁶

Conclusion: The Way Forward in Canada

To match the success in limb preservation that has been reported in some European countries, Australia and Alberta^{32,33} using the holistic approach outlined in this document, we propose that the Foot Health Pathway be adopted by all health regions in the Canada. While based on international evidence and best practice standards, this pathway can be adapted to fit the needs and resources of any health jurisdiction and successfully implemented, provided the general principles are met. As a tool for communicating to individuals, families, health providers, administrators, policy makers and funders, this pathway provides a person-centred, population health model based on risk and early and appropriate interventions. It outlines a stronger focus on risk screening and secondary and tertiary prevention using an integrated team approach that promotes foot health in people with diabetes. The ultimate goal is to prevent and/or reduce diabetes-related foot complications, including infection, ulcers, amputations and death.

Advocacy Efforts

Over the last several years, Wounds Canada and other stakeholders have advocated for research-suported policy changes.^{34–37} Among the recommendations is the need for:

- Providing universal access to preventative foot care services, including supplying preventative shoes, socks and offloading devices to those in need, free at the point of care, for all Canadians living with diabetes
- Developing policies that enable every Canadian with diabetes to have at least one foot assessment per year by a qualified health provider
- Adopting a Canada-wide interprofessional approach to diabetic foot care, with at least one multidisciplinary diabetes foot care team, with a well-defined referral pattern, in every health region
- Publishing, on an annual basis, reliable data on diabetes foot care, using internationally recognized metrics, to assist ongoing quality improvement efforts

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Useful Resources

For Clinicians

- Inlow's 60-second Diabetic Foot Screen
- Dépistage du pied diabétique en 60 secondes
- BPR Briefs: Diabetic Foot Ulcers
- Best Practice Recommendations for the Prevention and Management of Diabetic Foot Ulcers
- Product Picker: Offloading
- Wound Dressing Selection Guide

For Patients

- Caring for Your Feet: Safe Foot Care if You Have Diabetes
- Diabetic Foot Complications: When is it an emergency?
- Wound prevention and treatment: Do it yourself (DIY) or call in a pro? Neuropathic/Diabetic Foot Ulcer
- Diabetes, Healthy Feet and You pamphlet (available in 16 languages)
- Finding the Proper Shoe Fit (available in 16 languages)
- Foot Examinations for People with Diabetes

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Dr. Virginie Blanchette is the first podiatrist PhD in Québec and has been an associate professor in the podiatric medicine program at Université du Québec at Trois-Rivières since 2014. Her research specialty is prevention and management of diabetic foot ulcers and their complications, with a limb preservation approach within patient-oriented research. She is mentored by David G. Armstrong (Keck School of Medicine, University of Southern California) and is currently a Diabetes Action Canada trainee. She joined the Diabetic Foot Canada Task Force in 2019, is a member of the scientific committee of the Limb Preservation Symposium and a member of the Wounds Canada board of directors.

Mariam Botros is CEO of Wounds Canada and vice-president of D Foot International and is dedicated to empowering frontline clinicians, improving patient outcomes and improving health-care efficiencies. She

is a chiropodist and diabetes educator by training, with a master's degree in Educational Leadership. She has published widely, lectured extensively and supported the development, implementation and evaluation of many programs related to diabetic foot complications, wound care and amputation prevention nationally and internationally. In her various roles she has demonstrated her longstanding passion for community service, education and patient care.

Sue Rosenthal has been a freelance education and communications consultant for 42 years. She is the Director, Knowledge Mobilization, for Wounds Canada and is the founding and current editor of *Wound Care Canada* and founding and current co-editor, with Ahmed Kayssi, of *Limb Preservation in Canada*.

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Dr. Ide Costa is an advanced clinical nurse with expertise in the management of complex wounds. She was educated in both Brazil and Canada as a registered nurse, wound care specialist and researcher and has over 24 years of combined experience in clinical practice, teaching and research. Currently, she is an assistant professor in the School of Nursing and adjunct professor in the Faculty of Health Science at Lakehead University in Ontario. She practises wound care at her own clinic in Thunder Bay. She has been the recipient of multiple national and international awards in recognition of her outstanding work as a wound care nurse and researcher in Canada and Brazil. She is an advocate for improving timely access to wound care specialists for vulnerable populations and for empowering patients and families to take control of their own health.

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