Economic impact of diabetic foot ulcers and offloading treatment on the health care system in Canada

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BACKGROUND

- **10%** of Canadians are living with diagnosed diabetes [13]
- Canada spent **$21.7 billion CAD** on diabetes related expenditures in 2015 [24]
- A percentage of this spending is due to diabetic foot ulcers (DFU) [24]

Diabetic Foot Ulcers (DFU)
- Caused by **high mechanical tissue stress** in a diabetic foot with a loss of sensation [3]
- Can lead to **infection, hospitalization, and amputation** [24]
- Preceed **85% of non-traumatic lower-limb amputations** in the diabetic population [2]
- **Leading cause** of disability, mortality, and healthcare burden in Canada [24]

- Offloading devices are an **effective and important tool** in treating DFU [21, 3]
  - **Reduce plantar pressure** in the diabetic foot
  - Can lead to **better treatment outcomes**; amount and rate of ulcer healing
  - Examples: Total contact casting (TCC), removable cast walker, custom orthosis, offloading footwear and insoles

Figure 1: Types of offloading devices: [A] Total Contact Cast (TCC); [B] Non-removable walker; [C] Removable walker, [D] Offloading footwear; [E] Offloading insole

OBJECTIVE

1. Evaluate the economic impact of DFUs on the Canadian health care system to determine the efficacy of the redirection of health care resources towards offloading device funding
2. Evaluate offloading device outcomes in the management of DFU during active and remissive ulcer stages to assess their role in mitigating Canadian health care system costs

METHODS

A literature search was conducted utilizing EBSCO databases: Academic Search Complete, CINAHL, and MEDLINE. Additionally reference lists were manually searched for articles meeting the inclusion criteria, and research articles from Diabetes Canada were included.

Two separate search strings were utilized to capture the full range of research in this two part question. Synonyms related to diabetes, foot ulcers, were used in both strings. Synonyms related to health- care economics and canada were used for the economic string. Synonyms related to offloading devices and healing were used for the offloading string.

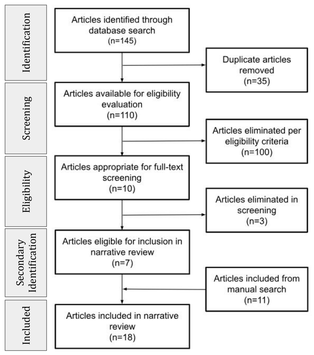


Figure 2: Canadian DFU economics search results

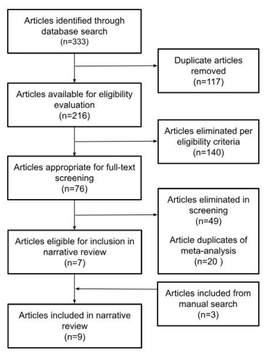


Figure 3: DFU offloading devices search results

Selection Criteria
Articles were included if available in English from peer reviewed journals published between 2000-2024, and met the below criteria.

Participants
Studies that solely focused on patients with diabetes with forefoot or midfoot ulcers were included. Patients with charcot neuroarthropathy or rearfoot ulcers were excluded. When analyzing economics this population was restricted to Canadian citizens. No restrictions were placed on age, sex, or other comorbidities.

Intervention
Studies utilizing any offloading devices. Treatment with surgery, or novel skin care were excluded.

Outcome Measures
Economics: Health care costs and pathways in treating DFU, savings in funding of offloading devices, amputations and post-op care burden
Offloading:
- Primary: amount of ulcer healing, healing rate
- Secondary: adherence, plantar pressure, cost-effectiveness, initial cost, amputation

Article Selection and Data Extraction
Assessment of the titles and abstracts of all articles retrieved from the initial databases search and manual search of review article reference lists were independently conducted by the investigators (CK and IZ) in accordance with the inclusion and exclusion criteria. Articles deemed fit for screening were then collaboratively reviewed by both investigators and a final list of articles was obtained. The full text articles were then analyzed and data extracted in relation to the stated outcome measures, and key findings summarized. Articles analyzed in included meta-analyses were cross-referenced with articles retrieved from the search strings and labeled as duplicates and therefore not formally included in data analysis.

RESULTS

Economic

Statistics regarding Diabetic Foot Ulcers in Canada

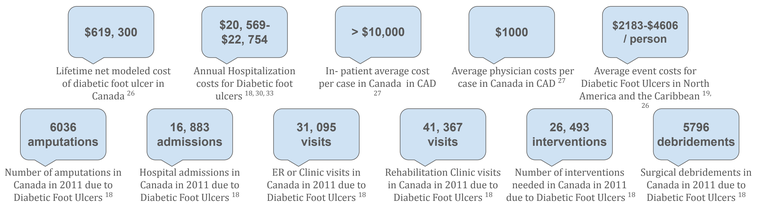


Figure 3: Statistics regarding the economic impact of Diabetic Foot Ulcers in Canada

Statistics regarding DFUs in Canada show the the lifetime net modeled cost of a DFU in Canada is $619,300 [26]. This is further broken down into hospitalization costs of $20, 569-22, 754/ year [18, 30, 33]; average inpatient cost of more than $10,000/case[27]; average physician costs of $1000/ case [27]; average events cost of $2183-4606/ person [9, 26]. Furthemore, in the year 2011, DFUs led to 6036 amputations [18], 16, 883 hospital admissions, 31, 095 ER/clinic visits [18], 41, 367 rehab clinic visits [18], 26, 493 interventions [18] and 5796 surgical debridements [18]. Since these figures were from the years 2011, due to the increase in the prevalence of diabetes since 2011, it can be extrapolated that these numbers are increased further in more than the last decade [27].

Provincial Direct Health Care Costs of DFUs by DFU Prevalence

Direct costs include hospital costs, physician visits, long-term care and home care costs. Findings show that the average yearly direct cost per DFU was greatest in Nova Scotia and lowest in Ontario. Following Nova Scotia, the provinces of Manitoba, Newfoundland and Alberta are the next highest spenders with similar yearly direct costs per DFU case. No data is reported for New Brunswick and Quebec [5-12].

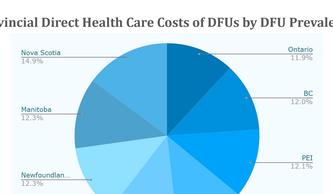
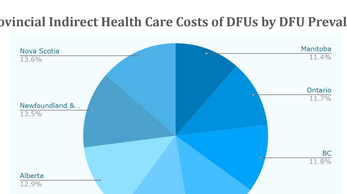


Figure 4: Ratio of provincial, average yearly direct health care costs per diabetic foot ulcer case (missing Quebec and New Brunswick)[5-12]

Provincial Indirect Health Care Costs of DFUs by DFU Prevalence



Indirect Cost include morbidity and premature mortality costs. Findings show that the the average indirect cost per DFU case was greatest in Nova Scotia and lowest in Manitoba. From lowest to highest, Manitoba is followed by Ontario, BC, PEI, Saskatchewan Alberta and Newfoundland respectively. No data is reported for New Brunswick and Quebec [5-12].

Figure 5: Ratio of provincial, average yearly indirect health care costs per diabetic foot ulcer case (missing Quebec and New Brunswick)[5-12]

Provincial direct costs of DFUs and net savings with offloading device funding

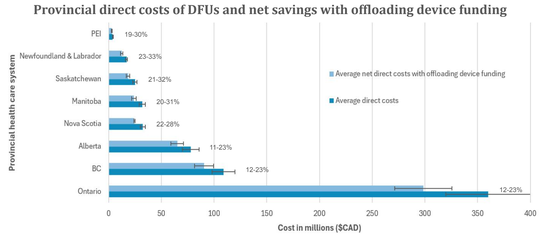


Figure 6: Comparison of yearly direct costs of DFUs to each provincial health care system with and without increased funding for offloading devices. Percentages are the percent cost reductions with funding [5-12].

Findings across the Canadian provinces show that Ontario had the greatest yearly direct costs to the healthcare system, with $320-400 million spent per year. Providing provincial funding for offloading devices for DFU management resulted in a yearly net cost reduction of an average of 22.68% across the provincial health care systems. The greatest percentage saving was seen in Newfoundland and Labrador at an average of 28% and the least was seen in Alberta at an average savings of 17% [5-12].

Provincial rates of amputations with and without use of offloading devices

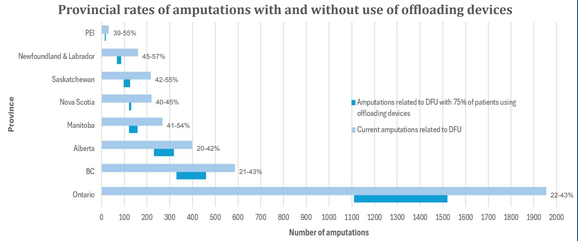


Figure 7: Amputations per province related to DFUs comparing current use and increased use of offloading devices for treatment of DFUs. Amputations related to DFU with 75% offloading use is represented as max and min values. Percentages are the percent amputation reductions per province with 75% offloading device use [5-12].

With 75% of patients with DFU using an offloading device, the number of amputations related to DFUs is reduced to between 20-43% for Ontario, BC, and Alberta, and between 38-57% for Manitoba, Nova Scotia, Saskatchewan, Newfoundland and Labrador and PEI [5-12].

Offloading

	Non-Removable vs. Removable	Total Contact Cast vs. Non-removable	Removable Knee-High vs. Removable Ankle-High	Offloading Device vs. Therapeutic Footwear
Ulcer Healing	↑ healing proportion, rate, time[17, 20, 23, 32]	Equal healing [17, 20]	Equal healing proportion [20]	↑ healing proportion [20], rate [23]
Plantar pressure	↑ pressure [20]	↑ pressure [20]	↓ pressure [20]	↓ pressure [20]
Adherence	↑ adherence [20]	-	↓ adherence [20]	-
Amputation	↓ amputations [20]	Equal amputations [20]	↑ amputations [20]	↓ amputations [20]
Health Equity	↓ equity [3]	↓ equity [3]	-	-
Initial Cost	↑ cost [20]	Equal cost [20]	↑ cost [20]	↑ cost [20]
Cost-Effectiveness	↑ cost-effectiveness [20]	↓ cost-effectiveness [20]	↑ cost-effectiveness [20]	↑ cost-effectiveness [20]

= large positive difference, = moderate positive difference, = little positive difference, = little-to-no difference, = little negative difference, = moderate negative difference

Figure 8: Primary and secondary outcomes related to different types of offloading devices used in the active forefoot or midfoot ulcer stage. (Colouring represents the magnitude of difference between the compared devices for each outcome and whether it is favourable [20]) .

Guidelines on offloading DFUs for people with neuropathic plantar forefoot or midfoot ulcers [3, 22]

1) Use a non-removable knee-high offloading device as a first choice of offloading
   - Either TCC or non-removable walker with a foot-device interface
   - Shown improved ulcer healing, enforced adherence, reduction in amputations, and cost effectiveness
   - Reduced health equity for those with low income due to initial costs or ongoing TCC material
2) Use a removable knee- or ankle-high offloading device as a second choice of offloading
   - Reduced ulcer healing and adherence to non-removable devices
   - Similar healing and reduce pressure, but knee-high devices can reduce adherence
3) Do not use conventional or standard therapeutic footwear over an offloading device
   - Offloading devices outperform therapeutic footwear in all outcomes except initial cost

	Insoles/Therapeutic Footwear vs. Standard Footwear	Pressure-optimized Insoles/Footwear vs. Standard Therapeutic Insoles/Footwear	Adherent to Therapeutic Footwear vs. Non-adherent to Therapeutic Footwear
Ulcer Recurrence	↓ risk or recurrence [31]	↓ risk or recurrence [31]	↓ risk or recurrence [31]
Plantar Pressure	↓ pressure [31]	↓ pressure [31]	-

= positive outcome, = negative outcome

Figure 9: Primary and secondary outcomes related to offloading footwear used in the remission stage and influence of adherence. (Colouring represents whether an outcome is favourable).

Guidelines on preventing recurrence of DFU [4, 31]

Prescription of therapeutic footwear that demonstrates relief of plantar pressure
≥30% reduction of peak in-shoe walking pressure (<200 kPa)

Consistent adherence to prescribed footwear

- Initial costs of therapeutic footwear with adequate offloading may be quite high [4]

Comparison of active and remission phase offloading prescription [22]
- Very different recommended offloading devices for active and remissive stage DFU
  - Knee-high non-removable device vs. therapeutic footwear
- Large drop in offloading capabilities between these devices & increased activity
  - Knee-high: 50-80 kPA vs. Therapeutic footwear: 200 kPa
  - Knee-high devices reduce activity levels

Increased pressure overload in remission may be causing high rates of re-ulceration [22]
- Propose a **transition period** to gradually reduce offloading treatment
  - (non-removable → removable → ankle-high → footwear) + gradual activity increase

DISCUSSION

Diabetic Foot Ulcers have a large economic impact on the Canadian Healthcare system
- Highest direct cost of DFUs → Ontario → $320-400 million [10]
- Highest direct cost per DFU case → Nova Scotia [9]
- Lowest cost per DFU case → Ontario [10]
- Lifetime net modeled cost of diabetic foot ulcers is $619,300 [26]

Provincial funding of offloading devices for DFU reduces Canadian healthcare costs
- Net cost reduction of an average of 22.68% all over Canada [5- 12]

Provincial funding of offloading devices reduces DFU related amputations [5-12]
- An average of 34%-49.5% reduction in number of diabetes related amputations with 75% of DFU patients using offloading devices [5-12]
- However no reduction in likelihood of premature mortality attributed to DFUs [5-12]

Figure 10: Ranking of offloading treatment for ulcer healing based on treatment standard [22]

Based on the assessment of primary and secondary outcomes, non-removable knee-high devices should be the first choice of offloading treatment if indicated or tolerated by the patient with either only mild infection or ischemia [3, 20, 22].

However, non-removable devices have lower health equity due to higher initial costs and/or ongoing material costs [3].
- Those of lower socioeconomic status may be unable to access the most beneficial offloading devices creating a cycle of inadequate treatment and prolonged reliance on the DFU health care systems [28].

With funding of offloading devices, better financial access to a higher level offloading devices may be achieved.
- Which then reduces the economic burden through reduced healing times possibly via forced-adherence, and eventually this can lead to a reduced number of amputations [3, 20, 22].

For the remission period of DFUs, pressure optimized therapeutic footwear/insoles are recommended [31].
- Which can then reduce the risk of ulcer recurrence and plantar pressure [31].
- Although not reported, costs of these footwear/insoles may be high due to modifications and testing for optimization [31].
- It is important to have funding for these devices to increase people's access to them which will minimize recurrence of DFUs and a continuous loop of relapse and remitting, which further financially burdening the healthcare system.

Funded offloading will support multiple device use during a transition period towards remission [22].
- Maintained high recurrence rate of ulcers may indicate a disparity in the offloading system [2].
- A suggested solution is creating a transition period of offloading devices that slowly reduces the offloading capabilities of the device [22].
- By limiting financial barriers to access multiple devices for a successful transition to regular footwear, the incidence of recurrent DFUs may be reduced and prove more cost-effective to the health care system by preventing more costly treatments in the longer run.
- Further research is needed to determine what devices and protocol a transition period should entail

LIMITATIONS

Economic Impact
- Publication year of economic reports (outdated)
- Inconsistent definitions of direct and indirect costs across studies
- Only Cohort or Retrospective Cohort studies available

Offloading
- Design of device - different manufacturers, cast walkers, application of TCC, device modifications and materials
- Lack of adherence reporting may limit reliable comparisons of healing
- Exclusion of patients with heel or rear-foot ulcers
- Lack of cost reporting for offloading devices

FUTURE DIRECTIONS

- Early intervention in DFU treatment with funding of offloading devices to reduce subsequent institutional costs associated with DFU treatments such as hospitalizations, long term care costs and debridement/amputation surgeries
- Creation of guidelines for the transition period (from ulcer healing in offloading devices to footwear) to reduce ulcer recurrence rates
- Education of mandatory design features to include in offloading devices that provide optimal healing and cost-effectiveness
- Development of strategies or resources to improve device adherence and subsequent cost-effectiveness of offloading devices
- Initiation of more Grassroots programs within the community, family doctor and allied health professional's offices for early identification of Diabetic Foot Ulcers (Ex: Socks Off Program through Hamilton Health Sciences)

CONCLUSION

Increasing the provincial funding of offloading devices to allow for greater access to non-removable devices for DFU management could effectively reduce Canadian healthcare costs

Provincial funding of offloading devices can yield an average of 22.68% net cost reductions over one year to the provincial health care systems [5-12]

With 75% of DFU patients using an offloading device, the number of amputations related to DFUs is reduced between 20-43% for Ontario, BC, and Alberta, and between 38-57% for Manitoba, Nova Scotia, Saskatchewan, Newfoundland and Labrador and PEI [5-12].

Non-removable offloading devices are the first choice of offloading treatment, improving ulcer healing and cost-effectiveness [3, 17, 20, 22, 23, 32]

Therapeutic footwear is recommended in the remission period of DFU care to reduce risk of recurrence [4, 31]

Reduced economic burden on the healthcare system with use of these devices [5-12]

References