Woundification Research Findings

Documentation for Woundification

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Research Overview

Context

Providence Health is a leading healthcare provider in British Columbia, Canada, with a Catholic ethos that drives its non-profit operations. With a focus on community engagement, the organization is committed to enhancing the health and well-being of the people it serves.

Providence Research now is pursuing the Woundification app project to understand its feasibility as a platform for wound care awareness and knowledge, aiming to develop a mid-fidelity prototype to identify wounds and aid healing progress; additionally, the project explores the possibility of making wound identification accessible to the general public and seeks to mature the idea for pitching to other partners or investors, with project deliverables geared towards this goal.

In 2023, a talented group of students, Team Esagono, selected Woundification as their first design and development project at The Centre for Digital Media. From January to April 2023, Esagono collaborated closely with Woundification. **This report of research findings, as part of the final deliverables, assisted us in understanding the project background, market value, and user habits, as well as providing constant action guides to current and future plan implementation.**

Methodology

For understanding the problem and needs of the wound application, the following methods will be utilized to guide our research and design stages.

- Define the research objectives
- Conduct secondary research and identify the problem
- Collect data- Survey, Interview
- Interpret findings
- Draw conclusions
- Discuss results

Research Objectives

Before starting the research, we obtained some preliminary research directions by understanding the client's needs, self-questioning, and attempting to answer them.

- What are the concepts included in wound care? What is the wound healing process? What are the steps in wound assessment? (See "Medical Concept Comprehension")

- What is the public's understanding of wound care and healthcare? What are the ways the public can access wound solutions? What is the most commonly used method? (See "Public Understanding of Wound Care")

- How much does Canadian spend on wound care? What is the most common type of wound in Canada? What is the type of wound that the public spends the most on? (See “Expense on Wound Care”)

- What are wound-identifying applications? What are the possible scenarios for the use of wound recognition applications? What is the advantage of using wound-identifying applications? (See “Introduction to Wound-identifying Applications”)

- What are the external forces towards wound care(wound-identifying) applications in British Columbia, Canada? (See PESTEL Analysis)

- Who are the competitors of wound care(wound-identifying) applications in Canada? What are their key features? How is their market performance? What is the biggest product problem currently faced by wound care applications? (See “Competitor Research”)

- What are the awareness, attitude, and actions toward wound-identifying applications on the user’s end? What are the user’s true needs regarding wound care applications? How can we balance non-medical and medical suggestions? What kind of suggestion we could provide in the context of a laceration wound assessment? (See “User Research”)

- What are the technologies used in wound-identifying applications? How difficult is their implementation? What’s the number of databases that are available for reference, general wounds and specific wounds? (See “Technical Research”)

This report will explain and discuss the list of questions mentioned above.

Medical Concept – Wound Knowledge

To holistically comprehend the concept of wound care, we started by probing into a range of fundamental wound knowledge, which includes the definition of the wound, wound care wound healing process, wound types, and the general wound assessment process. Additionally, we also look into minor wounds that seemingly are easier addressed on an application.

Wound and Wound Care

A wound refers to a condition that involves harm to living tissue, commonly arising when the skin's integrity is disrupted. A wound can happen at any time. Adults could wound themselves when cooking, cleaning, or gardening, while children could get injured during a bad fall at home or while playing.

The general public is frequently acquainted with common wound types, including cuts, scrapes, blisters, and minor burns, often from their own personal experiences. However, more severe wounds, such as deep or extensive injuries, like stab wounds, gunshot wounds, major burns, and various types of surgical incisions, can significantly impact the individual's overall health and well-being.

Proper wound care involves several steps, which can vary depending on the type and severity of the wound. Normally, take the following seven steps that help the wound recover.

1. Clean the wound: Gently clean the wound with soap and water or a sterile saline solution. Avoid using hydrogen peroxide, iodine, or alcohol, as they can damage tissue and delay healing. Additionally, preventing infection is critical in wound care, therefore make sure whoever is applying wound care washes their hands.

2. Control bleeding: Apply pressure to the wound with a clean cloth or bandage until the bleeding stops.

3. Apply an antibiotic ointment: This can help prevent infection and promote healing.

4. Cover the wound: Cover the wound with a sterile bandage or dressing to protect it from dirt and further injury.

5. Change the dressing regularly: Change the dressing at least once a day or more often if it becomes wet or dirty.

6. Watch for signs of infection: Symptoms of infection include redness, swelling, warmth, and increased pain. If you notice any of these signs, contact your healthcare provider.

7. Keep the wound elevated: Elevating the wound can help reduce swelling and promote healing.

References

- Bueno, Simone. “7 Steps for Caring for Wounds | Corner Stone Urgent Care Center.” *Corner Stone Urgent Care Center*, 8 Oct. 2021, https://www.cornerstoneuc.com/2021/10/08/7-steps-for-caring-for-wounds/.
- “First Aid True or False – Caring for Cuts, Scrapes, Burns, Wounds.” *WebMD*, https://www.facebook.com/WebMD, https://www.webmd.com/first-aid/ss/slideshow-wound-care-dos-and-donts. Accessed 28 Mar. 2023.
- “Wounds Defined - Wounds Canada.” *Home - Wounds Canada*, https://www.facebook.com/pages/Canadian-Association-of-Wound-Care/175552905826240, http://www.woundscanada.ca/members-of-the-media/overview-media/woundsdefined. Accessed 28 Mar. 2023.

Types of Wounds (Based on Wound Condition)

Based on the presence or absence of a break in the skin or mucous membrane, and the mechanism of injury that caused the wound, wounds can be classified into two types: open wounds and closed wounds. More details on the types of wounds are provided below.

Reference:

- Types of Wounds | Kindred Hospitals.” *Kindred*, http://www.kindredhospitals.com/our-services/ltac/conditions/wound-care. Accessed 28 Mar. 2023.

Open Wounds

Open wounds are wounds that break the skin's surface, allowing air and bacteria to enter the body. Examples of open wounds include:

Penetrating Wounds

- **Puncture wounds:** These are wounds that occur when a sharp object, such as a nail or needle, punctures the skin. These wounds can be deep and may damage underlying tissue.
- **Abrasions:** Also known as scrapes, these are wounds that occur when the skin is rubbed or scraped off, typically by a rough surface.
- **Lacerations:** These are wounds that occur when the skin is cut or torn. They can be deep or shallow and can occur anywhere on the body.
- **Avulsions:** These are wounds that occur when a portion of the skin and underlying tissue is torn away from the body. These can be severe and may require surgery to repair.
- **Thermal, Chemical, and Electrical Burns:** These are burns caused by contact with fire, hot objects, hot liquids, chemicals such as acids, and alkalis, or by contact with

an electrical current. They can range from mild to severe depending on the intensity of the heat and the duration of exposure. Symptoms can include redness, blistering, and pain.

Blunt Force Trauma

- **Abrasions**: These are wounds that occur when the skin is rubbed or scraped off, typically by a rough surface. The top layer of skin called the epidermis, is scraped away, but the underlying tissue is not usually damaged.
- **Lacerations**: These are wounds that occur when the skin is cut or torn. They can be deep or shallow and can occur anywhere on the body.
- **Skin tears**: These are wounds that occur when the top layer of skin is torn away from the underlying tissue, often due to friction or shearing forces. They are common in older adults and individuals with fragile skin.

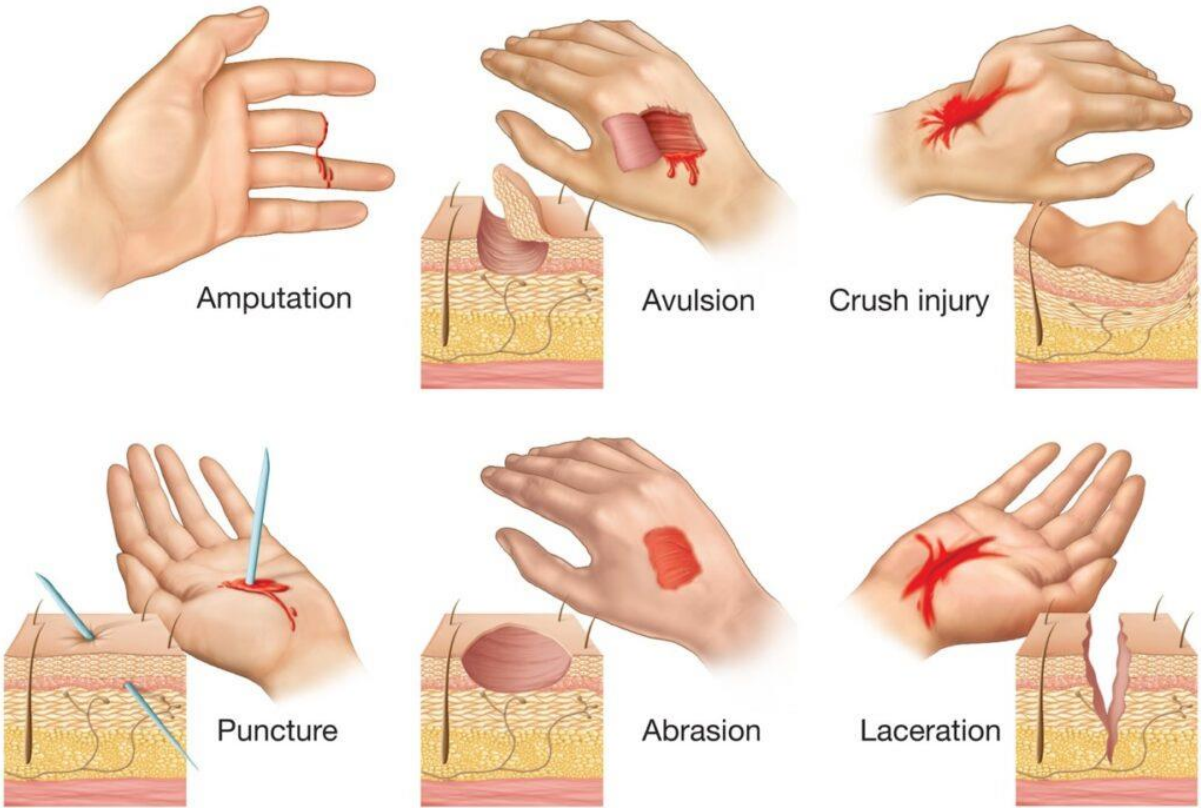


Figure 1: Illustration of several open wounds, Source: https://mychn.org/wound-care/

Closed Wounds

Closed wounds are wounds that do not break the skin's surface. Examples of closed wounds include:

- **Contusions:** also known as bruises, these are wounds that occur when the skin is hit or bumped. Blood vessels beneath the skin are damaged, causing blood to pool beneath the skin and creating a visible bruise.

- **Seroma:** A seroma is a pocket of clear serous fluid that sometimes develops after surgery or an injury. It can occur in any area of the body but is most commonly found in the abdomen, breasts, and armpits. Seromas can cause pain, swelling, and discomfort, and may require drainage.
- **Hematoma:** A hematoma is a localized collection of blood outside of blood vessels, usually caused by trauma to the tissue. Hematomas can occur in any part of the body and can vary in size. Symptoms may include redness, swelling, and pain at the site of the injury.
- **Ulcer:** An ulcer is an open sore or wound that occurs on the skin or mucous membrane. Ulcers can be caused by a variety of factors, including injury, infection, and poor circulation. They can be painful and may take a long time to heal.

Reference

"Types of Wounds | Kindred Hospitals." *Kindred*, https://www.kindredhospitals.com/our-services/ltac/conditions/wound-care. Accessed 29 Mar. 2023.

Types of Wounds (Based on Wound Duration)

Wounds can also be classified based on whether they follow the normal phases of healing (see "Wound Healing Process").

Acute Wounds

Acute wounds are wounds that typically heal within a relatively short period of time, usually within **four weeks**. In healthy individuals, most wounds heal on their own over time with minimal intervention. These wounds follow a typical healing process that progresses through several phases, including hemostasis, inflammation, proliferation, and maturation and remodeling.

Chronic Wounds

In contrast, chronic wounds are wounds that fail to heal within the expected time frame, usually due to underlying health conditions or other factors that impede the healing process. Chronic wounds can take months or even years to heal and often require specialized treatment. Chronic wounds are a significant health problem, particularly for individuals with comorbidities such as diabetes, peripheral artery disease, or heart disease. Examples of chronic wounds include venous ulcers, arterial ulcers, diabetic ulcers, and pressure ulcers. These wounds can significantly impact an individual's quality of life and may lead to serious complications such as limb amputations or systemic infections.

Factors Contributing to Chronic Non-Healing Wounds

- Diabetes, anemia, cancer, obesity, and other long-term medical conditions including arthritis and kidney disease
- Heart issues, such as high blood pressure, heart disease, or varicose veins Immobility, such as being confined to a wheelchair or bed
- Harmful habits such as smoking, an unhealthy diet, or inactivity
- A weakened immune system from chemotherapy, immunosuppressive medications, or medical conditions like AIDS
- Infected wounds
- Circulation problems
- A history of ulcers
- Certain medications

Wound Healing Process

When a wound occurs, the body immediately initiates a complex series of physiological processes that work together to close the wound, reduce the risk of infection, promote tissue regeneration, and restore normal function.

The wound healing process typically involves four main stages:

- Hemostasis (stopping bleeding)
- Inflammation (destroying bacteria and removing debris)
- Proliferation (rebuilding new tissue)
- Remodeling (strengthening and refining the new tissue).

This process can vary in duration and intensity depending on the type and severity of the wound, as well as various other factors such as age, overall health, and underlying medical conditions.

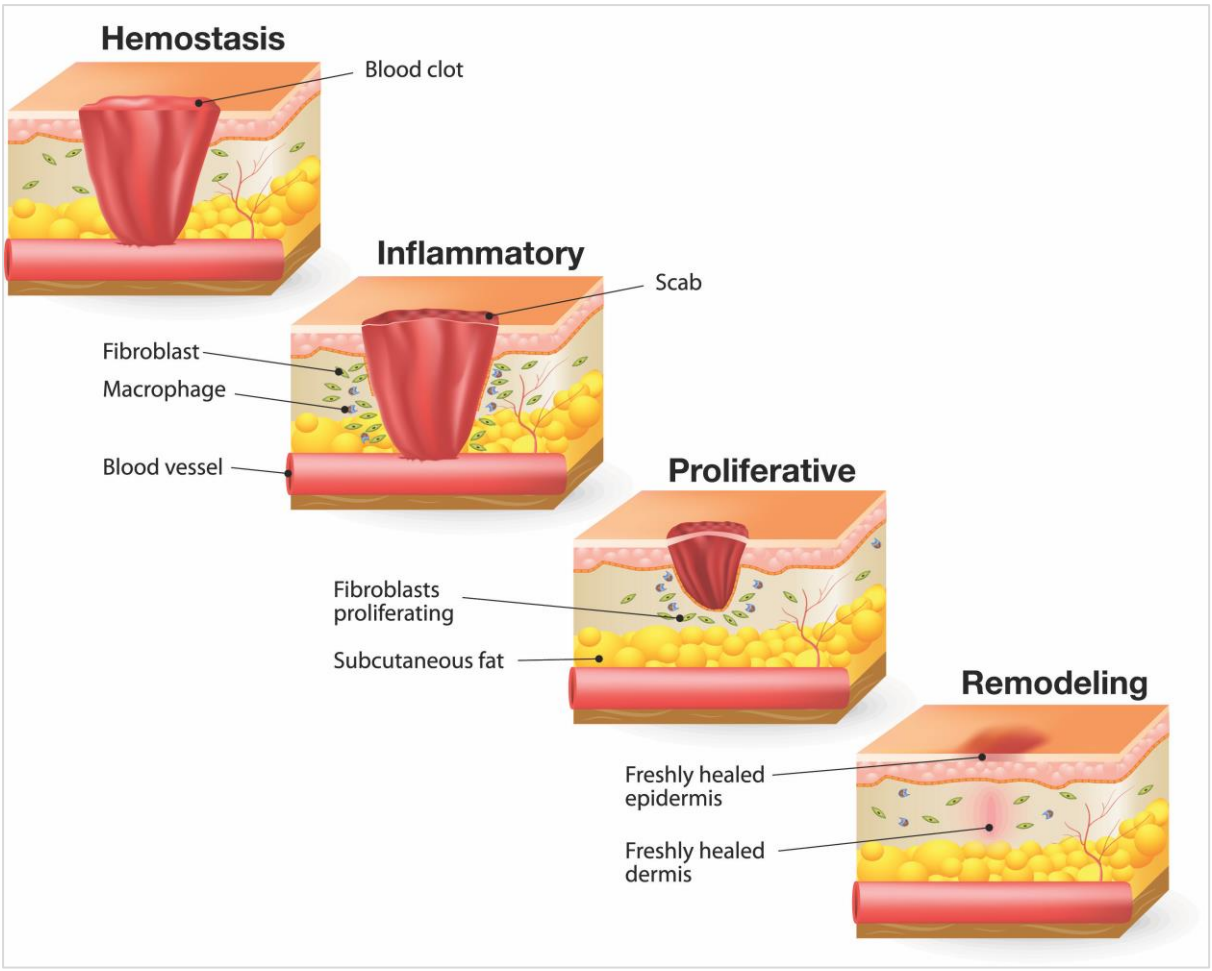


Figure 2: Wound healing process

Reference:

- Maynard, John. "How Wounds Heal: The 4 Main Phases of Wound Healing | Shield HealthCare." *Shield HealthCare*, 18 Dec. 2015, http://www.shieldhealthcare.com/community/popular/2015/12/18/how-wounds-heal-the-4-main-phases-of-wound-healing/.

Wound Assessment Process

Regarding the prevention and management of acute and chronic wounds, the American Federal Bureau of Prisons developed a basic wound care algorithm in 2014. It consists:

- **Basic initial wound assessment**
  - Wound history
  - Wound assessment
  - Basic vascular exam

- **Identify the type of wound**
    - Pressure ulcerations
    - Arterial insufficiency
    - Venous insufficiency
    - Neuropathic disease/Diabetic foot ulcers
- **Alleviate the mechanism of injury for identified wound type**
- **Establish a treatment plan and healing goal based on the wound bed color(s)**
- **Evaluate a 2-week healing goal**
- **Review wounds not meeting healing goals**

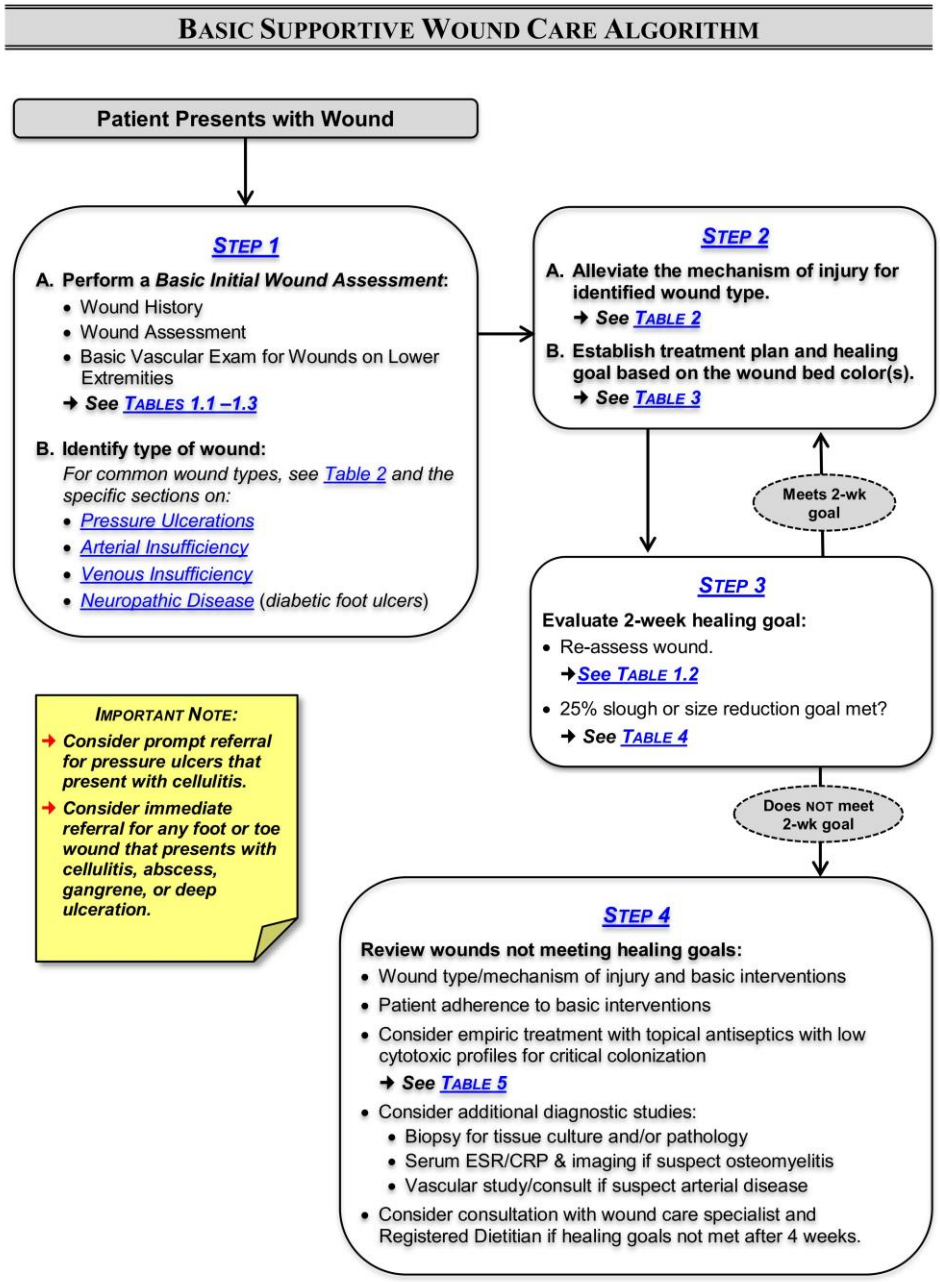


Figure 3: Basic supportive wound care algorithm

TABLES FOR BASIC WOUND CARE ALGORITHM

TABLE 1.1: WOUND HISTORY	
Onset	When did it first occur? Is it recurrent? What is the patient's description of the cause of the wound?
Prior Treatment and Diagnostic Work	Dressings? Antibiotic use? Offloading or prevention strategies to alleviate mechanism of injury? Diagnostic tests? Previous consultations/referrals?
Past Pain	Past pain and pain level related to the wound(s)? Interventions tried for relief? Effectiveness of interventions?

TABLE 1.2: WOUND ASSESSMENT	
Parameters	**Descriptors**
Location	Anatomical site

Size/Volume	***L x W x D (cm)*** (L x W for wounds without depth)
	Always measure in centimeters (cm) the longest measure for each axis:
	• ***Length:*** 12–6 o'clock measure in cm
	• ***Width:*** 9–3 o'clock measure in cm
	• ***Depth:*** deepest point in cm
	  • If no depth, document "no appreciable depth."
	  • If wound covered with slough/dry necrotic tissue, document as "indeterminate."
	  • Note any tunneling or undermining.

Wound Bed	Estimate percentage of colors (e.g., black, brown, yellow, grey, red, green).
Drainage	• Amount (none, scant, moderate, or copious) • Color • Odor (none, mild, moderate, or strong). • Moisture balance (surrounding skin is not wet; dressing is not adhered to wound bed). Is the drainage well contained by the dressing?
Surrounding Skin	• Intact or not intact? Color? Is there a palpable temperature change? • How does it feel to palpation: supple (normal), soft (fluctuant), or hard (indurated)? Does it blanch?
Current Pain	Location, scale, quality, qualities, onset, duration, exacerbating/relieving factors, comments

Barriers to Healing	***Intrinsic:***
	  • Ability to comprehend and understand instructions
	  • Any physical limitations or mobility issues that may affect healing
	  • Willingness to be an active participant in care and treatment
	Extrinsic:
	  • Equipment not available
	  • Institution specific limitations: building, housing, terrain challenges
	  • Correctional/security challenges

***For more details**, see discussion of Wound Assessment under Step 1A.*	

TABLE 1.3: BASIC VASCULAR EXAM FOR WOUNDS ON THE LOWER EXTREMITIES		
Appearance of Skin	• Color/discoloration • Edema	• Distribution of hair
Vascular Assessment	• Skin temperature • Capillary refill (in seconds) • Palpation of dorsalis pedis and post-tibial pulses	• Presence of dependent rubor • Pallor elevation test
***For more details**, see discussion of Basic Vascular Exam under Step 1A.*		

Table 1: Tables for basic wound care algorithm

TABLE 2: WOUND TYPE AND MECHANISM OF INJURY

Wound Type	Mechanism of Injury	Basic Interventions
Pressure Ulcerations	Pressure over ulceration	Offload or limit pressure over the area around the ulcer (sitting and/or lying). Sleep surface and wheelchair cushion must be in accordance with CMS criteria. Provide a shower cushion, when needed. ★ If cellulitis present, consider prompt referral for treatment. ★ If ulcer tunnels near the bone, review *STEP 4* of algorithm: Suspect osteomyelitis.
Arterial Insufficiency	Decreased arterial blood flow in limb	Limit constriction and elevation of affected area. Keep warm and protect from injury (e.g., thick socks, extra layer of clothing). External heating devices are not recommended due to potential for burns. Provide padding over the ulcer (e.g., extra layers of gauze). ★ If ulcers are on toes or heels, may need a wheelchair and wound shoe to offload wounds. ➔ *If cellulitis, abscess, gangrene, or deep ulceration is present, consider immediate referral for treatment and amputation prevention.*
Venous Insufficiency	Venous congestion/edema	*Short term*, consider elasticated tubular bandage size F (e.g., Medigrip™ or Tubigrip™); use ACE wraps and TED hose if no other alternatives are available or acceptable to the patient. Ambulate to tolerance. ★ Consider consultation (e.g., with physical therapist; wound or vascular specialist) for safe, *long-term* compression.
Neuropathic Disease (*diabetic foot ulcers*)	Change in foot sensation and/or structure (poor fitting footwear)	Maintain good glycemic control. Recommend limited weight bearing on affected foot; may need a wheelchair and wound-healing shoe (not the same as a diabetic shoe) to offload wounds. Callous debridement by qualified provider may be needed. Once resolved, recommend medical footwear and foot care for life. ➔ *If cellulitis, abscess, gangrene, or deep ulceration is present, consider immediate referral for treatment and amputation prevention.*
Skin Infection	MRSA or other infections	See the BOP Clinical Practice Guidelines for *Management of MRSA Infections* and for *Antimicrobial Stewardship Guidance*. If there is a residual wound after treatment of the infection, then follow the *Basic Supportive Wound Care Algorithm* in conjunction with these guidelines.
KEY: ★ = critical decision points; ➔ = potential life or limb threatening issue		
For more in-depth review of interventions *to alleviate specific mechanisms of injury, see the sections under Common Wound Types which provide more detailed discussions.*		

Table 2: Tables for basic wound care algorithm

TABLE 3: WOUND COLOR, GOALS, AND TREATMENT FOR HEALING A WOUND

Wound Bed Color*	2-Week Healing Goal	Treatment**
Mostly black tissue	Discuss therapy goal with provider: *healing* vs. *stabilization*	***Healing*** = see "mostly mixed colors" in next row below ***Stabilization*** = Povidone-Iodine and gauze 1–2 times/day. ★ See *General Therapy Goals: Healing, Stabilization, and Palliation* in Section 2 under *General Concepts*. ★ If black tissue on heels or toes, see *caution with black heels and toes* under STEP 2B discussion. ★ For alternatives to iodine, see section on *Use of Topical Antiseptics*. ➔ *If signs of cellulitis on foot or toes, consider immediate referral.*
Mostly mixed colors: red/pink/yellow/brown/ black	25% reduction in yellow slough	Rinse with normal saline (NS), and apply NS-moistened gauze to wound. Cover with gauze and/or ABD, secure with tape OR consider collagenase (Santyl®) 1–2 times a day, nickel thickness to entire wound. ★ If yellow/ brown/black tissue is dry, consider removing the dry roof or cross-hatching—by qualified provider—to optimize therapy. See the description of *conservative sharp debridement*. ★ Healing goals are not calculated until most of the dry yellow/brown/black tissue is removed.
Mostly red or pink	25% reduction in size	Rinse with normal saline (NS), and apply NS-moistened, gauze to wound. Cover with gauze and/or ABD, secure with tape
Healed/intact skin	Remains healed x 2 weeks	Protect the wound bed and apply OTC topical moisturizer if dry. ★ Continue interventions used to alleviate mechanism of injury and consider long-term interventions for mechanism of injury.

KEY: ★ = critical decision points; ➔ = potential life or limb threatening issue

* ***For a more in-depth review and examples***, *see discussion under STEP 2B: Establish Treatment Plan and Healing Goal, Based on the Wound Bed Color(s).*

** ***Unless otherwise indicated, dressings are to be changed daily or less often.*** *At each dressing change, the wound is assessed for moisture balance and containment of drainage. Moisture balance is adjusted by adding or subtracting the amount of saline used when applying the dressing. If moisture balance is difficult to establish with normal saline and gauze, consider using an alternative dressing type listed in Appendix 2, Basic Dressing Types. Notify the provider if unable to establish good moisture balance. For a more thorough discussion, see Key Principles of Topical Therapy under STEP 2B.*

Table 3: Tables for basic wound care algorithm

TABLE 4: ASSESSMENT OF 2-WEEK HEALING GOAL
Wound Re-assessment Criteria
See *Table 1.2* for criteria.
Percentage of Slough Reduction
Only for yellow slough: = 1 – (current % wound slough/previous % wound slough) = % slough reduction = %
Percentage Size Reduction Calculation
1 – (new size/previous size) = % size reduction *Note that there are some minor differences for the following:* • Wound without depth • Wound with depth • Comparing a wound which previously had measurable depth and now does not
***For examples** of slough reduction and size reduction calculations, see Step 3: Evaluate 2-Week Healing Goal.*

TABLE 5: TOPICAL ANTISEPTICS WITH LOW CYTOTOXIC PROFILES FOR EMPIRIC TREATMENT OF CRITICAL COLONIZATION		
Agent	**Frequency**	**Special Instructions**
Silvadene® 1% cream (silver sulfadiazine)	2–3 times a day	Nickel thickness to entire wound; avoid letting cream dry out. → *Caution if patient has sulfa allergy.*
Iodasorb® gel 0.9% ointment (cadexomer iodine)	daily to every 3 days	Nickel thickness to entire wound; changes color as it absorbs drainage. Light yellow signals time to change. *Caution: Color change should not be confused for pus.* ***Dose limit:*** 50g per application or 150 g per week. → *Caution if patient has iodine allergy.* → *Contraindicated for patients with thyroid disorders, and for pregnant or breastfeeding patients*
0.25% acetic acid solution (1/4 strength acetic acid)	1–2 times a day	Deliver on moistened gauze and adjust dressing for moisture balance (not too wet, not too dry). → *Undiluted solution can cause serious acid-related injury to tissue and bone.*
KEY: → = potential life or limb threatening issue		
***Treat with one of the above antiseptics for two weeks.** If healing goals are met, then return to basic treatment listed in Table 3. If no improvement, consider a different agent listed above in this table.* ***For more in-depth review**, see Use of Antibiotics for Wound Care: Topical and Systemic and Use of Topical Antiseptics.*		

Table 4: Tables for basic wound care algorithm

Other wound care practitioners conclude similar algorism for wound assessment as well. The infection Prevention and Control Program of Winnipeg Regional Health Authority (2009) created a pamphlet on wound bed assessment and management algorithm, clarifying the

logical and practical standard process of wound assessment that is commonly used in Canadian medical institutions. The primary steps of assessing a wound contain:

- Wound history
- Wound location
- Wound size
- Degree of tissue damage
- Wound bed appearance
- Wound exudate(drainage)

Noted to check if the wound has an adequate blood supply to heal. **If there is NO potential for healing due to inadequate blood supply**, moist interactive local wound care is contraindicated. **The application of topical antiseptics to dry the wound and prevent bacterial invasion is recommended**.

References

- Prevention and Management of Acute and Chronic Wounds [USA Federal Bureau of Prisons Clinical Practice Guidelines, March 2014] https://www.bop.gov/resources/pdfs/wounds.pdf
- The Infection Prevention and Control Program of Winnipeg Regional Health Authority https://www.wrha.mb.ca/extranet/eipt/files/EIPT-013-003.pdf

Feature: Minor Wounds

Considering the complexity of wounds that involve joints, nerves, flexor tendons, or other underlying structures that may require operative care and specialized approaches to treatment that cannot be provided by a mobile application alone, specifically, we also explore the basic treatment for minor wounds.

Minor wounds are typically small cuts, scrapes, or puncture wounds that affect the skin or superficial tissues. They may be caused by accidents such as falling, bumping into an object, or cutting oneself with a sharp object. Minor wounds usually heal on their own within a few days to a week, without requiring extensive medical treatment. Most minor wounds in children occur on the head, and the most common mechanism of injury is the application of blunt force.

Minor wounds are one of the most common wounds globally. However, minor wounds are a broad concept because they can refer to a variety of types of injuries that are generally not considered to be severe or life-threatening. For different minor wounds in different locations, self-treatment could also be different due to cosmetic and medical considerations. (See “Suggestions for Laceration”). In this case, we need to specify and narrow down the type of wounds as well in order to provide valuable personalized suggestions.

Management of these minor wounds has two goals: avoidance of infection and achievement of a functional scar that is cosmetically acceptable.

For minor wounds assessment, physicians are suggested to consider these aspects:

- Determination of allergies (e.g., to local anesthetics, antibiotics, or latex)
- Status of tetanus immunization

Wound management and tetanus prophylaxis

Previous doses of tetanus toxoid*	Clean and minor wound		All other wounds¶	
	Tetanus toxoid-containing vaccine$^{\Delta}$	Human tetanus immune globulin	Tetanus toxoid-containing vaccine$^{\Delta}$	Human tetanus immune globulin$^{\diamond}$
<3 doses or unknown	Yes§	No	Yes§	Yes
≥3 doses	Only if last dose given ≥10 years ago	No	Only if last dose given ≥5 years ago$^{¥}$	No

Table 5: Wound management and tetanus prophylaxis

Wound age

- Most simple lacerations that are small (eg, <5 cm in length), do not have gross contamination, and are not located on the lower extremities can be closed up to 12 to 18 hours later with little risk of infection.

Mechanism of injury

- Low risk: A simple cut through the skin by a sharp object causes minimal damage to the surrounding tissues and has a relatively low risk for infection or significant scarring.
- Moderate risk: Tearing of the skin, as occurs when the chin strikes the floor, produces irregular wound margins and damage to the surrounding tissues; these lacerations have a moderate risk of infection and scarring.
- High risk: Direct compression injuries, as occur from a blow to the head, split the skin, injure the adjacent soft tissues, and classically cause a stellate laceration; these wounds have the highest risk of infection.
- Other specific situations: Animal and human bites, crush injuries, and stab wounds.

Presence of the foreign body

- If the object can be reliably palpated, the wound can be minimally extended to remove it, provided there is no risk to underlying structures.
- Irritant material, such as wooden splinters, can be a source of later infection and should be removed.
- A nonirritant foreign body, such as glass or metal that is not in a critical area (eg, a joint space) or adjacent to a vital structure (eg, a major blood vessel) and will not cause ongoing irritation may be left in place if unable to be removed, and the wound sutured.

The bed of the wound, neurovascular, or tendon injury

- Injury to underlying structures, such as a fracture beneath a laceration or penetration of joint space in a finger laceration, has significant implications for management.
- The position of the body part at the time of injury must be considered. As an example, an injury might be missed if a laceration occurred with the finger in flexion and the wound is inspected only with the digit in extension. Similarly, the ends of a tendon that has been completely severed may retract from view.

Cosmetic significance of the wound

- Wounds in cosmetically sensitive areas, such as large wounds that involve the vermilion border of the lip, cartilaginous regions of the nose or ear, or facial lacerations that have tissue missing will present a challenge to good cosmetic outcomes.
- The orientation of the wound relative to skin tension lines affects cosmetic outcomes. Relaxed skin tension lines (RSTL) arise from the normal draping of skin on the body(eg, lines on the back angle slightly downward and away from the spine) and from muscle tone and body movement (eg, forehead wrinkles). **Wounds that are oriented perpendicular to these lines have greater potential for scarring.**

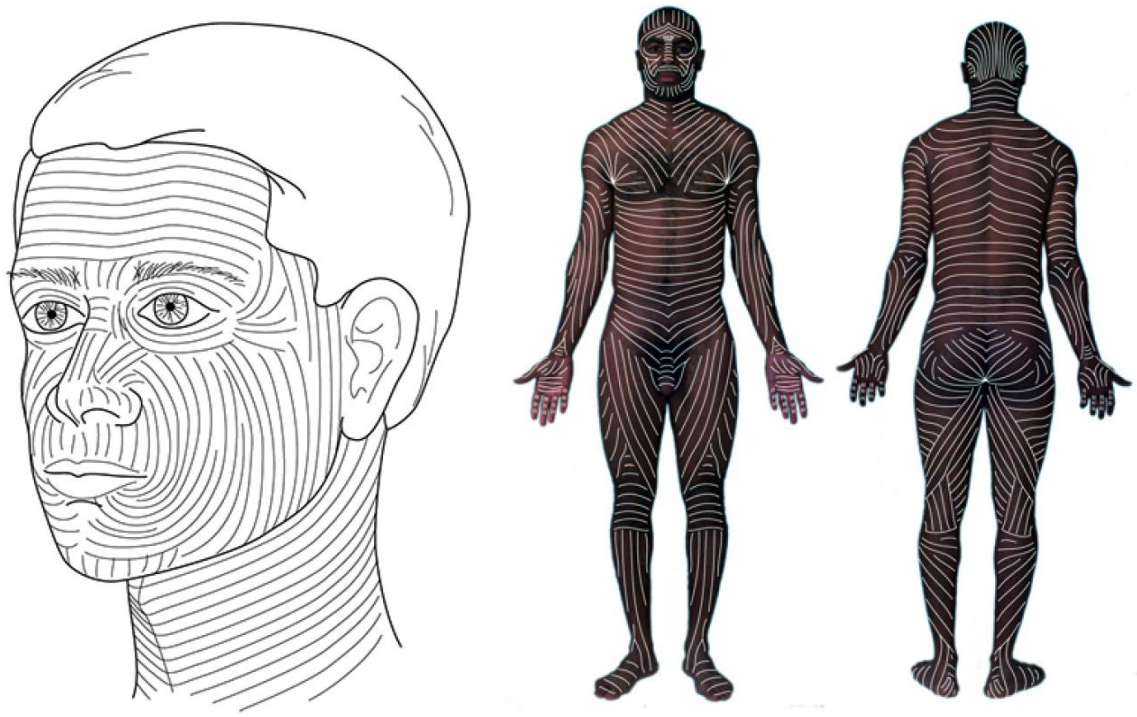


Figure 4: Langer's lines on the face and the body

Reference:

- Minor wound evaluation and preparation for closure, John C Brancato (January 2023)

Market Research

Market research is crucial for understanding the wound care market and trends. It helps identify the needs and wants of healthcare professionals, patients, and caregivers, and the features they want in a wound care app. It also identifies competition, strengths, and weaknesses to develop a unique selling proposition. This information can be used to create a marketing plan and set goals for the app's success.

Public Understanding of Wound Care

The extent to which the public comprehends wound care and healthcare may differ based on their educational background, gender, income, cultural surroundings, and individual encounters. **Generally, people understand that proper wound care is important for preventing infection and promoting healing**. **However, they may not be familiar with the specific techniques and products used in wound care.** For example, research from the Asser region (2021) shows that over 97% of people believe that hands should be washed prior to changing wound dressing and only around 30% of people agree that vaseline is beneficial for reducing wound scars.

There are several ways the public can access wound care solutions. **One of the most common ways is through their healthcare providers, such as a doctor or nurses**. They may also be able to purchase wound care products over the counter at a pharmacy or online, or they may be prescribed specific products by their healthcare provider.

For individuals, the most commonly used method for wound care depends on the type of wound and its severity. For minor wounds, such as small cuts or scrapes, simple first aid techniques like cleaning the wound and applying a bandage may be sufficient. For more serious wounds, such as deep cuts or surgical incisions, more advanced wound care techniques may be necessary, such as the use of specialized dressings or topical medications.

Users have the tendency to use digital devices and suggest providing easy-to-use information products that enhance wound care knowledge. In a cross-sectional survey that is conducted in Taiwan, most participants responded that it is important to apply mobile health technology in wound care while most of them had not used mHealth technology for wound care.

Content	Negative (score 0, 2.5[a]) n (%)	Neutral (score 5[a]) n (%)	Positive (score 7.5, 10[a]) n (%)
It is important to use mobile health technology in wound care.	16 (4.4)	164 (45.4)	181 (50.2)
The use of mobile health technology in wound care can be helpful in improving wound care outcomes.	16 (4.4)	109 (30.2)	236 (65.4)
Wound care information products should be optimized for mobile devices.	22 (6.1)	129 (35.7)	210 (58.2)
Wound care information products should be easy to use.	20 (5.6)	99 (27.4)	242 (67.0)
I am interested in how mobile health technology can help me take care of wounds.	14 (3.9)	92 (25.5)	255 (70.6)

[a]Arithmetic scale: 10=strongly agree, 7.5=agree, 5=neutral, 2.5=disagree, 0=strongly disagree.

Table 6: Mobile health technology use of participants (n=361), from a survey in Taiwan (2020)

References:

- Knowledge, Attitudes, and Practices Regarding Wound Care among General Population in Aseer Region - PMC." *PubMed Central (PMC)*, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8144783/. Accessed 28 Mar. 2023.
- Wound Care Knowledge, Attitudes, and Practices and Mobile Health Technology Use in the Home Environment: Cross-Sectional Survey of Social Network Users - PMC." *PubMed Central (PMC)*, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7146246/. Accessed 28 Mar. 2023.

Expense on Wound Care

Wound care covers a large portion of the healthcare market in Canada.

- Canada spends $ 3.9 billion annually on wound care (2011).
- 30% - 50% of all healthcare involves a wound in Canada (2011).
- If essential care is postponed or improperly delivered, patients are 20x more likely to end up in the hospital.
- If essential care is postponed or improperly delivered, patients are 10x – 40x more likely to need an amputation.

In Canada and around the world, the most common types of wounds are minor injuries. These wounds usually do not require specialized medical attention and can be treated at home with basic wound care techniques. As for the type of wound that the public spends the most on, it is difficult to provide a definitive answer as it can vary widely depending on the individual case.

In general, chronic wounds, such as pressure ulcers, diabetic foot ulcers, and venous leg ulcers, tend to be more expensive to treat due to the need for ongoing care and specialized wound dressings or treatments. These types of wounds can also lead to complications and

require longer hospital stays, further adding to the overall cost of treatment. **6.5 million** people in North America have chronic wounds that require ongoing care.

With early screening, persons with diabetes who are at high risk for developing a foot ulcer could receive appropriate offloading, education and follow-up that will prevent a wound from occurring.

If left until an ulcer develops, the costs increase significantly over the costs for prevention. The total direct-care cost of diabetic foot ulcers to the Canadian healthcare system was determined by Hopkins et al. to be $547 million (2011 dollars), with an average cost per case at $21,371. If the wound becomes chronic, the cost over three years climbs to $52,360.

Personal and societal costs are significant as well. In a study reported by Hopkins et al., where patients with diabetic foot ulcers were followed for three years, the mortality rate was 26.4%. When a diabetic foot ulcer leads to an amputation, the mortality rate jumps to about 50% at five years.

Reference:

- "Burden of Wounds in Canada - Wounds Canada." *Home - Wounds Canada*, https://www.facebook.com/pages/Canadian-Association-of-Wound-Care/175552905826240, https://www.woundscanada.ca/members-of-the-media/overview-media/burden-of-wounds-in-canada. Accessed 28 Mar. 2023.
- "Human Wound and Its Burden: Updated 2020 Compendium of Estimates - PMC." *PubMed Central (PMC)*, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8024242/. Accessed 28 Mar. 2023.
- OHA, and OACCAC. *Four Pillars: Recommendation for Achieving a High-Performing Health System*. 2011.

Introduction to Wound-identifying Applications

Wound-identifying mobile applications are smartphone or tablet apps designed to assist healthcare professionals and individuals in identifying, understanding, and documenting wounds. These apps typically use the device's camera to capture images of the wound, which can then be analyzed and categorized based on various factors such as wound type, size, location, and severity. These applications utilize advanced technologies, such as artificial intelligence, machine learning, and image recognition, to provide accurate wound assessments and track wound healing progress over time. The ultimate goal of wound identification applications is to improve patient outcomes by facilitating precise wound assessment and effective wound care management.

Today, the development of smartphone apps and digital medical devices provides a chance for significant advancements in wound management by integrating smart technologies into clinical practice.

The use of online mobile applications with different functions could supply many potential scenarios that require wound care management.

Hospitals and Professional Places

Recognizing and Evaluating: To help primary care providers provide care for their patients with chronic wounds.

- Fraiwan et al. (2017) developed an ulcer detection device that uses a smartphone app and a mobile thermal camera (FLIR ONE). The device was tested on four images taken with the thermal camera and smartphone to demonstrate that skin regions with hyperthermia, with a temperature gradient of more than 2.2°C, reflect potential ulcers. The researchers found that the proposed method was efficient in helping diabetic patients to self-check their feet and to recognize vulnerable areas effectively, which can aid in the prevention of foot ulcers.

Achieving and Documentation: To help nurses and physicians reduce the number of hospital-acquired pressure injuries at a community hospital through accurate documentation and identification of pressure injuries upon admission.

- The use of wound apps is on the rise, with more healthcare professionals and patients utilizing these apps for wound assessment and management. According to a survey of 154 healthcare professionals, 67% of them used wound apps in their clinical practice, and the most commonly reported benefits of using wound apps were improved accuracy and efficiency in wound assessment and documentation.
- In 2018, Nair conducted a study to assess the use of digital imagery for better documentation and analysis, and to improve productivity. The digital imagery application was specifically designed to measure and document wounds effectively. This non-invasive software was cost-effective, time-saving, and user-friendly. It also provided greater photographic clarity to promote multidisciplinary discussion, as well as lower errors in clinical wound-management documentation. Patients and caregivers could also use the application to track wounds at home.

Home or other personal spaces:

In terms of patient demand, a survey conducted by Wakefield Research in 2018 found that 46% of 1,000 adults surveyed would use a mobile app to track their wound healing progress, while 36% believed that a wound app would help them better manage their wound care. A 2018 study published in the Journal of Medical Internet Research surveyed 360 adults with diabetes and found that 81% of them were willing to use a mobile app for wound care management. Similarly, another study published in the Journal of Wound Care in 2018 surveyed 98 patients with chronic wounds and found that 81% of them were interested in using a wound app to manage their wound care.

Knowledge Sharing: To empower laymen who lack enough wound care knowledge and help them to seek the proper treatment.

- Most patient-centered applications provide on-demand access to educational articles and videos.
- Provide access to 24/7 automated and agent support.

Reminder: To help patients and caregivers to track their wound progress.

Prediction: To help patients predict their wound healing.

- Wang et al., (2017) created a smartphone application (See "Swift Wound app") that allowed non-contact surface area and temperature measurements. The study addressed peri-wound temperature rise as a typical sign of infection but skin temperature is not always measured during wound assessments. In addition, Swift Skin and Wound use artificial intelligence to accurately measure the wound circumference, type and progress.

Medical Material Ordering: To help patients purchase dressings and other medical materials online.

- MyWoundHealing mobile app provides seamless and personalized supply **reorders directly in the app** saving valuable time.

Additionally, wound apps are perceived to have benefits such as improved **wound healing outcomes**, **greater patient engagement**, and **improved communication between patients and healthcare providers**.

It's important to mention that younger patients, those with higher education levels, and those who are comfortable with technology are more inclined to use wound management wapps.

Reference:

- Zhang, Z., Zhu, J., Weijs, F., van Dijk, L., Wouters, M. S. M. H., & Bachmann, L. M. (2021). The Use of Mobile Applications in Wound Care: A Literature Review and Data Analysis. International Journal of Environmental Research and Public Health, 18(2), 508. https://doi.org/10.3390/ijerph18020508)
- The Use of Online Applications to Improve Chronic Wound Care in The Use of Online Applications to Improve Chronic Wound Care in Primary Care; A Literature Review Primary Care; A Literature Review (2020)https://repository.usfca.edu/cgi/viewcontent.cgi?article=1041&context=dnp_qualifying
- **MyWoundHealing™ Mobile App** https://www.mywoundhealing.com/mobileapp

PESTEL Analysis

In order to provide valuable insights into the various factors that may impact the development, adoption, and use of wound care technologies in Canada, particularly in British

Columbia, we used the PESTEL tool to systematically evaluate the external factors that may influence the development and use of wound care applications in these regions.

Political Factor

- There are many NGOs across Canada that promote wound care.
    - **Wounds Canada(https://www.woundscanada.ca/):** Established in 1995, Wounds Canada is a charitable organization dedicated to the advancement of wound prevention and management. Their goal is to reduce the prevalence and incidence of wounds of all types and the negative consequences they bring—including patient suffering and wasted healthcare dollars.
    - **The Chronic Wound Care Alliance of Canada:** This alliance brings together healthcare professionals, patients, and industry partners to promote excellence in chronic wound care through education, advocacy, and research.
- The British Columbia Government obtained consistent financial support regarding long-term home and community care from the Minster of Health.
    - The Ministry of Health 2021/22 – 2023/24 Service Plan mentions that the B.C. government is investing $548 million for the year 2021-2023 to improve care for seniors, including investments in primary care, home and community care, long-term care, and assisted living.

Annual Funding for Home and Community Care and Mental Health and Addictions Services

Fiscal Year	Home and community care Estimated amount to be paid to British Columbia * (subject to annual adjustment)	Mental health and addictions services Estimated amount to be paid to British Columbia * (subject to annual adjustment)
2018-2019	$78,740,000	$32,810,000
2019-2020	$85,300,000	$59,050,000
2020-2021	$85,300,000	$78,740,000
2021-2022	$118,110,000	$78,740,000

* Amounts represent annual estimates based on StatCan 2017 population

Table 7: Annual Funding for Home and Community Care and Mental health and Addiction Services

Economical Factor

- A potential and enormous wound care market is yet to be explored.
- The financial implications are significant as costs associated with amputations are approximately $1.5 billion.

Sociocultural Factor

- Public concerns about the correction, and discrimination of medical identifying apps that may delay the proper treatment.
- Fortunately, clinical evidence is eliminating doubts from the public.
    - The reliability of wound surface measurements using a mobile app against the traditional ruler method was tested by Seat and Seat in 2017. This research showed that the mobile wound assessment software (Tissue Analysis) provided reasonably reliable outcomes to be useful in the practical management of chronic wounds and looked to be greater than the ruler method.

Technological Factor

- There are well-established and clinically proven wound-identifying products and technologies on the market.
    - Swift Wound (2017): The study addressed peri-wound temperature rise as a typical sign of infection but skin temperature is not always measured during wound assessments.

Environmental Factor

Non-touchable services is aligning with the climate policy that reduces medical waste.

- The Canadian Net-Zero Emissions Accountability Act, which became law on June 29, 2021, enshrines in legislation Canada's commitment to achieving net-zero emissions by 2050. British Columbia has put into place, or plans to put into place, provincial net-zero-by-2050 legislation.

Legal Factor

Artificial intelligence and machine learning

- On 2021 October 27th, The U.S. Food and Drug Administration (FDA), Health Canada, and the United Kingdom's Medicines and Healthcare products Regulatory Agency (MHRA) jointly identified 10 guiding principles that can inform the development of **Good Machine Learning Practices (GMLP)**. These guiding principles will help promote safe, effective, and high-quality medical devices that use artificial intelligence and machine learning (AI/ML). Including, Training Data Sets Are Independent of Test Sets and Testing Demonstrates Device Performance During Clinically Relevant Conditions.

Data privacy

- **Personal Information Protection Act (PIPA):** PIPA is a provincial law that governs the collection, use, and disclosure of personal information by private sector organizations in British Columbia. It sets out rules for obtaining consent,

safeguarding personal information, and providing individuals with access to their information.

- **Federal Personal Information Protection and Electronic Documents Act (PIPEDA):** PIPEDA is a federal law that applies to organizations that collect, use, or disclose personal information in the course of commercial activity. It sets out rules for obtaining consent, safeguarding personal information, and providing individuals with access to their information.
- **Canadian Anti-Spam Legislation (CASL):** CASL is a federal law that governs commercial electronic messages, including emails, texts, and instant messages. It sets out rules for obtaining consent, identifying the sender, and providing recipients with an unsubscribe mechanism.

Intellectual property rights

- Trademarks Act
- Copyright Act
- Patent Act
- Trade Secrets Act

Regulatory compliance

- **Food and Drugs Act:** If the mobile app is intended to be used in connection with a health product, such as a medical device, it may be subject to the Food and Drugs Act. This Act governs the sale and distribution of health products in Canada and sets out requirements for product safety and efficacy.

Reference:

- Ministry of Health 2021/22 - 2023/24 Service Plan - BC Budget https://www.bcbudget.gov.bc.ca/2021/sp/pdf/ministry/hlth.pdf
- Government of Canada Invests close to $134 million to Support Canadians Living and Working in Long-Term Care in British Columbia https://www.canada.ca/en/health-canada/news/2021/08/government-of-canada-invests-close-to-134-million-to-support-canadians-living-and-working-in-long-term-care-in-british-columbia.html

Competitor Research

The goal of competitor analysis is to Identify market opportunities and threats. By analyzing our competitors, we can identify gaps in the market that our app can fill, as well as potential threats to our business from existing or new competitors. According to this research, we will complete the following tasks:

1. Identify market opportunities and threats
2. Find the areas that we can offer and make improvement

3. Set realistic goals and benchmarks for our product

Swift Skin and Wounds

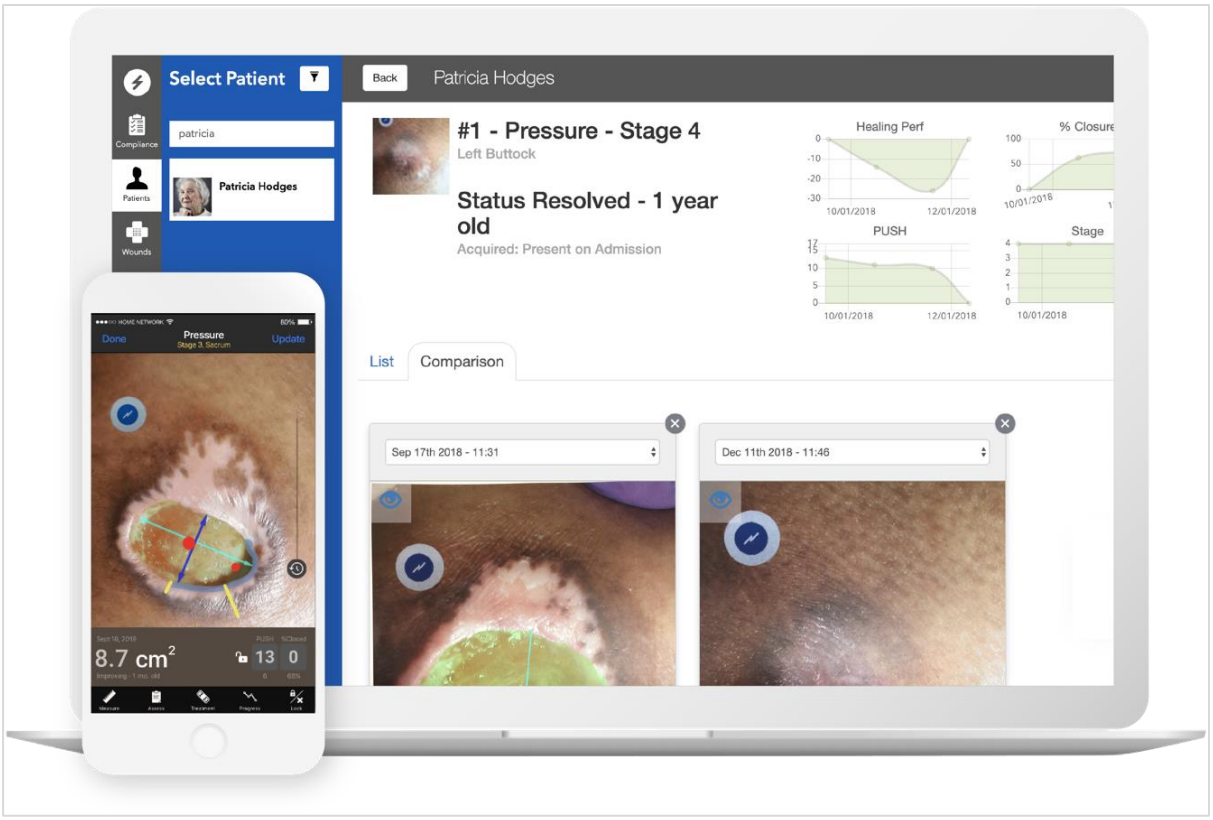
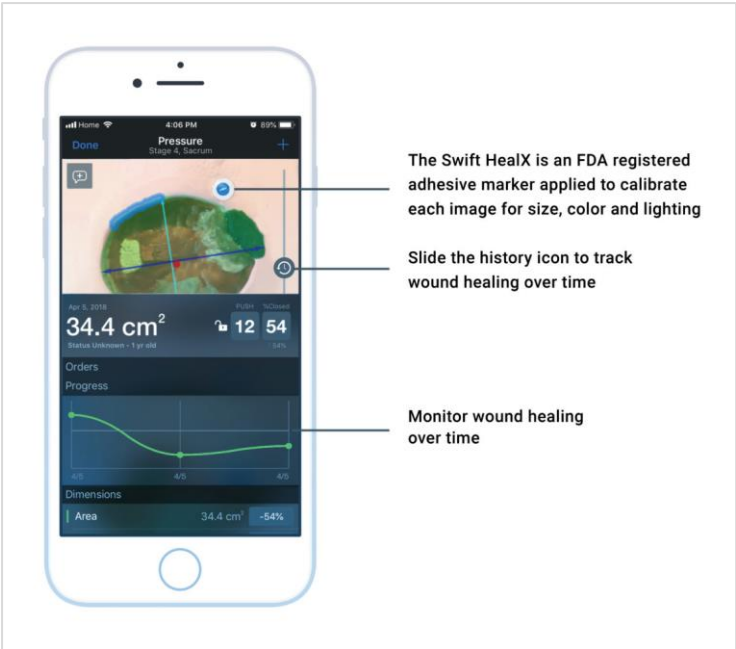


Figure 5 Swift Skin and Wound application interface with desktop dashboard



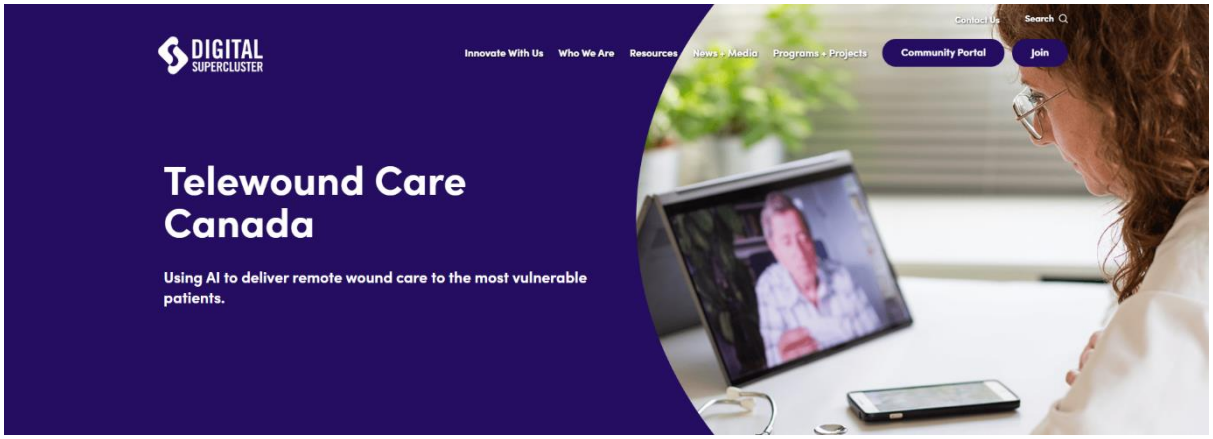
Platforms: iOS and Android.

This app helps to heal more than 10,000 wounds a month in over 1,000 healthcare facilities throughout the United States. It uses depth-sensing analysis from photos only and HealX marker-based calibration. The app is targeted toward healthcare professionals, and the Swift dashboard provides detailed data.

According to a 2017 study, this is the first app clinically validated

for measuring wound size and temperature at the point of care. The app employs thermal imaging using an infrared FLIR one camera to detect localized changes in skin surface temperature, identify signs of inflammation or infection, and monitor changes in wound size over time.

The Telewound Care Canada Project



The Telewound Care Canada project aims to provide remote wound care management to patients, particularly those in rural and remote areas who may not have easy access to wound care specialists. The project uses telemedicine technology to connect patients with wound care specialists, who can assess and monitor their wounds remotely. This approach can reduce the need for patients to travel long distances for wound care appointments, which can be particularly difficult for those with mobility issues or other health concerns.

Led by Swift Medical, this project brings together SE Health, AlayaCare, and several healthcare and academic institutions in Canada.

The project is still in its early stages, but it has the potential to significantly improve access to wound care for patients across Canada. The use of telemedicine technology in wound care has been shown to be effective in several studies, improving patient outcomes and reducing healthcare costs. The Telewound Care Canada project is an exciting development in the field of wound care, and it will be interesting to see how it evolves in the coming years.

As of June 15, 2022, the project has secured a great deal of funding.

- Project budget: $4.3 million
- Partner co-investment: $0.8 million
- Supercluster co-investment: $3.5 million

Reference

https://www.telewound.ca/

Swift Ray 1

Figure 6: Swift Ray 1 Device

Swift Ray 1 is the next generation of wound identification technology by Swift Medical. This is the world's first hyperspectral device that fits in your pocket and allows you to measure the invisible. It provides quantifiable measurements, such as oxygen levels with light, bacteria presence with UV light, and the formation of wounds with thermal imaging.

Reference

- *The Swift Ray 1*. https://info.swiftmedical.com/the-swift-ray-1. Accessed 29 Mar. 2023.

Pin An health (Website)

Functions: 1. Online diagnosis: write down the symptoms, or you can select the illness or upload pictures. Before the diagnosis, you need to add your personal information. Then, choose the way of communicating with doctors (audio, pictures, video, and choose the doctors) 2. medical experts: the app list out the information of doctors, and patients can select directly. (Paid content) 3. medical examination 4. Online drugstore: based on your location, the app will recommend nearby drugstores or online drugstores. 5. Push-News: health-related news

Goal：Ping An Health will adhere to the value proposition of "save effort, save time and save money," with the vision of "let every enterprise have a happy workplace, let every family have

an exclusive doctor, and let every user have a safe health", build a professional doctor-patient bridge and guard the health of all people with heart and soul.

Conclusion: it has diverse functions to provide holistic health-related services. but all diagnosis part is conducted by humans instead of AI.

Reference:

- https://www.jk.cn

Net Health (Formerly Wound Expert)

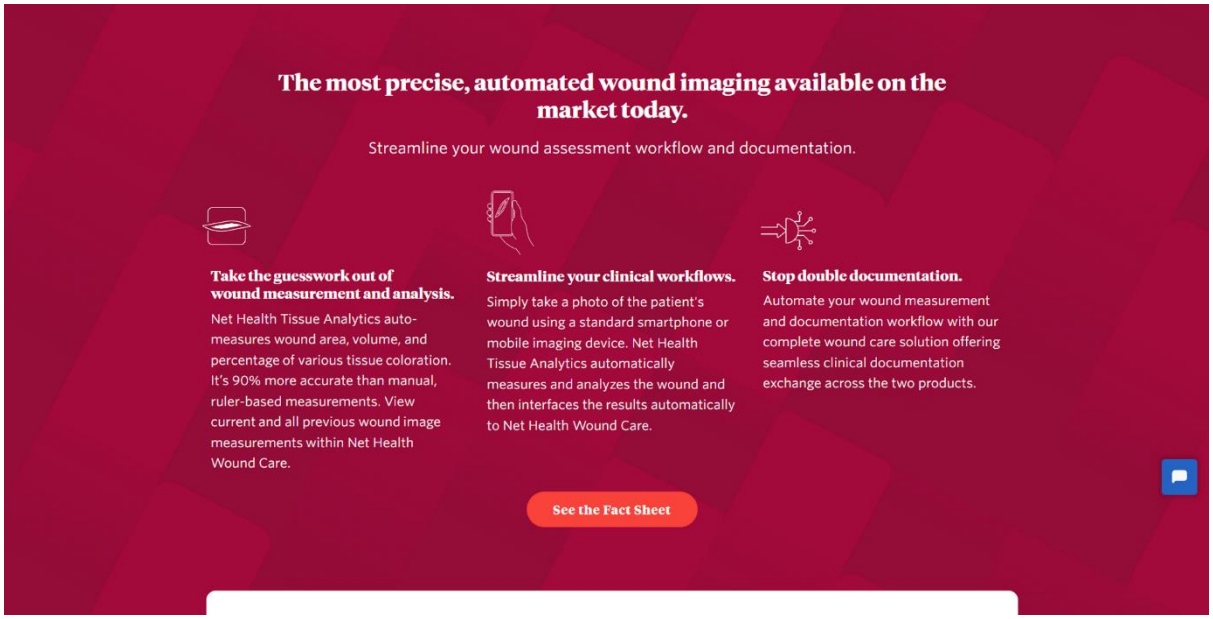


Figure 7: Net Health product features

Net Health Wound Care And Tissue Analytics for Outpatient Clinics (Formerly WoundExpert) is a web-based electronic medical record system that provides tools for managing wound care patients. It includes features such as wound assessment, treatment plans, and progress tracking.

Goal: Net Health aims to improve the quality of care for wound patients by providing a centralized platform for wound care management.

Advantages: Net Health allows for easy tracking of patient progress and provides tools for creating customized treatment plans. It also allows for secure, HIPAA-compliant communication between healthcare providers.

Disadvantages: This is a subscription-based service, so there may be costs associated with its use.

Reference

- https://www.nethealth.com/solutions/woundexpert/

WoundRounds (App)

Functions: WoundRounds is a mobile app that provides wound assessment and treatment tracking tools. It allows users to take photos of wounds and record measurements, as well as create and manage treatment plans.

Goal: WoundRounds aims to improve wound care by providing real-time data on wound progress and facilitating communication between healthcare providers.

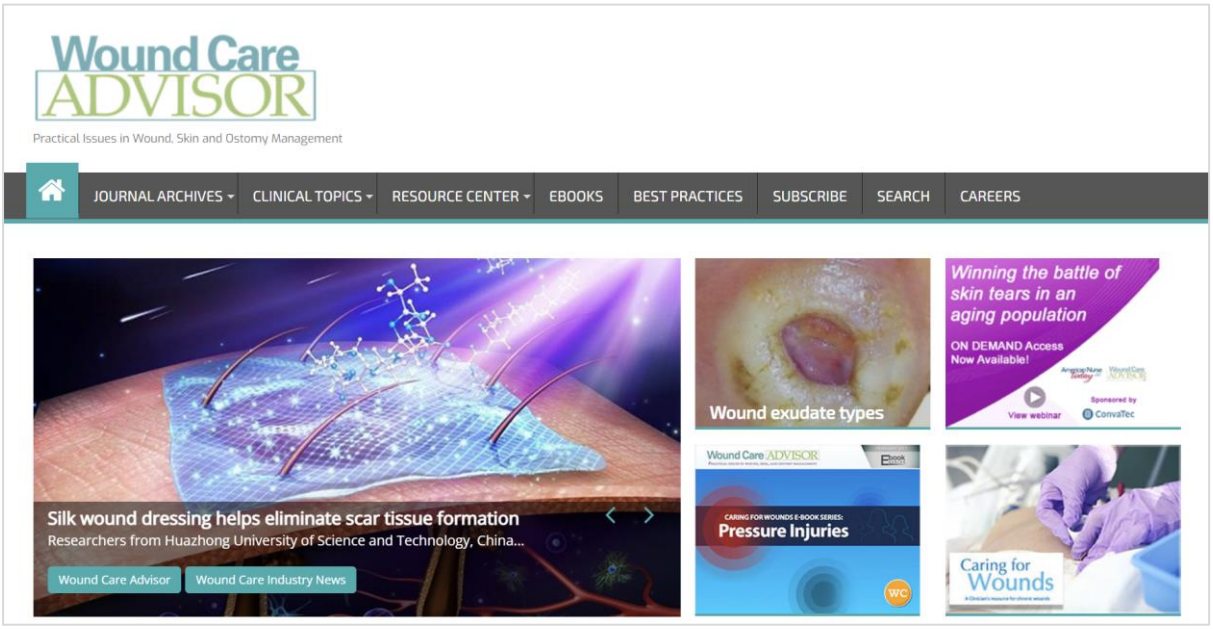
Advantages: WoundRounds allows for easy documentation and tracking of wound progress, which can improve patient outcomes. It also facilitates communication between healthcare providers, reducing the risk of miscommunication.

Disadvantages: WoundRounds is a subscription-based service, so there may be costs associated with its use. It also requires a mobile device with a camera to use.

Reference:

- https://www.woundrounds.com/

Wound Care Advisor (Website)



Functions: Wound Care Advisor is a website that provides educational resources and tools for wound care professionals. It includes articles, videos, and webinars on various topics related to wound care.

Goal: Wound Care Advisor aims to improve wound care knowledge and skills among healthcare providers, ultimately improving patient outcomes.

Advantages: Wound Care Advisor provides a wealth of educational resources on wound care, making it a valuable tool for healthcare providers. It is also free to use.

Disadvantages: Wound Care Advisor does not provide tools for wound assessment or treatment tracking.

Reference:

- https://woundcareadvisor.com/

Wound Care App (App)

Functions: Wound Care App is a mobile app that provides tools for wound assessment and treatment tracking. It includes features such as wound measurement, documentation, and photo capture.

Goal: Wound Care App aims to improve wound care by providing a mobile platform for wound assessment and treatment tracking.

Advantages: Wound Care App allows for easy documentation and tracking of wound progress, which can improve patient outcomes. It also allows for easy communication between healthcare providers.

Disadvantages: Wound Care App is a subscription-based service, so there may be costs associated with its use.

Reference:

- https://www.woundcareapp.com/

Key Conclusions of Competitors

Opportunities

- Most of the current products are aimed at professionals and practitioners, with slightly providing self-monitoring functions for patients at the home. A new wound care app could benefit from expanding its user base beyond healthcare professionals to include patients and caregivers for more comprehensive wound care management.
- To increase the stickiness of the mobile application and build a continuous business model, chronic wound patients should be highly considered as this group focuses on long-term health care. Otherwise, consider the portability and easy-to-access of the digital product which users could get information via websites or native plugs-in programs(such as chrome plugs or chatbot on Facebook Messenger, etc)
- Non-touchable and Non-invasive application has the potential to significantly improve access to wound care for patients in remote areas and reduce the need for long-distance travel for wound care appointments.
- Image measurement causes miscalculations of wound borders by the app's algorithms. A new wound care app could benefit from improving the accuracy and reliability of its quantifiable measurements to ensure the effectiveness of wound care.
- Accurate measurement requires special devices that use multiple wavelengths of NIR(Near Infrared Ray) light to measure relative amounts of oxygenated and deoxygenated hemoglobin in the microcirculation where oxygen exchange is happening.

Threats

- Leading products have advanced technologies and build the high technical barriers. For example, Swift Wound stands out for thermal imaging, 3D measuring and AI prediction of healing, and which requires massive investment in R&D and helps them stay the dominant position in the market.
- Physician may be highly involved and support the community together. Most of them offer only an indicative tool, not a diagnostic tool, as the final diagnosis should be made by a physician.

Wound Care Applications for Elderly Individuals

According to the research, we found that diabetics are one of the populations that can benefit significantly from wound apps. Diabetes is a chronic condition that can lead to various complications, including slow wound healing and the development of diabetic foot ulcers (DFUs). DFUs are a common problem for individuals with diabetes, and early detection and treatment can significantly improve healing outcomes and prevent more severe complications such as amputations.

Several studies have investigated the demand for wound apps among individuals with diabetes, and the results indicate that there is a significant interest in using these apps to manage wound care. A 2018 study published in the Journal of Medical Internet Research surveyed 360 adults with diabetes and found that 81% of them were willing to use a mobile app for wound care management. The study also found that patients who reported higher levels of comfort with technology and greater self-efficacy in managing their diabetes were more likely to use wound apps.

Another study published in the Journal of Wound Care in 2018 surveyed 98 patients with chronic wounds, including DFUs, and found that 81% of them were interested in using a wound app to manage their wound care. The study found that patients who were more engaged in their wound care and had greater knowledge of wound care were more likely to use wound apps.

The benefits of wound apps for diabetics are numerous. Wound apps can help patients track and monitor their wound healing progress, record and share wound images with healthcare providers, receive personalized wound care instructions, and receive reminders for appointments and medication schedules. Wound apps can also provide patients with educational resources on wound care and diabetes management and connect patients with a network of healthcare professionals who can provide additional support and guidance.

Overall, the target users are primarily middle-aged individuals, elderly individuals, and those with chronic diseases.

Prevalence – 2022	Diabetes (type 1 + type 2 diagnosed + type 2 undiagnosed)	Diabetes (type 1 and type 2 diagnosed)	Diabetes (type 1 + type 2 diagnosed + type 2 undiagnosed) and prediabetes combined	Cost
BC	825,000 / 16%	577,000 / 11%	1,636,000 / 31%	$565M
AB	575,000 / 12%	403,000 / 8%	1,242,000 / 26%	$494M
SK	161,000 / 13%	113,000 / 9%	334,000 / 26%	$111M
MB	283,000 / 18%	151,000 / 10%	412,000 / 28%	$152M
ON	2,346,000 / 15%	1,643,000 / 10%	4,713,000 / 30%	$1.7B
NL	102,000 / 19%	72,000 / 13%	190,000 / 35%	$70M
PE	25,000 / 15%	17,000 / 11%	50,000 / 31%	$19M
NS	173,000 / 17%	121,000 / 12%	335,000 / 33%	$114M
NB	152,000 / 19%	106,000 / 14%	274,000 / 35%	$110M
Canada	5,719,000 / 14%	4,003,000 / 10%	11,704,000 / 30%	

Prevalence (1)	**2022**	**2032**
Diabetes (type 1 + type 2 diagnosed + type 2 undiagnosed)	825,000 / 16%	1,075,000 / 19%
Diabetes (type 1 and type 2 diagnosed)	577,000 / 11%	753,000 / 13%
Diabetes (type 1)	5-10% of diabetes prevalence	
Diabetes (type 1 + type 2 diagnosed + type 2 undiagnosed) and prediabetes combined	1,636,000 / 31%	1,970,000 / 35%
Increase in diabetes (type 1 and type 2 diagnosed), 2022-2032	30%	30%
Direct cost to the health care system	$565 million	$732 million
Out-of-pocket cost per year (2)		

Type 1 diabetes on multiple daily insulin injections	$800–$2,800	
Type 1 diabetes on insulin pump therapy	$800–$4,700	
Type 2 diabetes on oral medication	$1,500–$1,900	

Figure 8: The statistics of the number of diabetics and expenditure in Canada.

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User Research

During the product ideation phase, we conducted several interviews to get first-hand user data for analysis and to provide suggestions for prototype iteration in the context of a laceration wound assessment.

User Research Objectives

Before designing the user research, we listed out the questions that need to be clarified.

- Do my users have impairments or disabilities to consider–whether temporary, situational, or permanent?
- How familiar are my users with technology?
- How are my users accessing the product or service?
- Where and when are my users accessing the product or service?
- Have I considered all my potential users?

Interview - Version 1 (New Wound)

To better understand the needs of users, we conducted a survey to figure out how people treat.

Demographic Information

Number of participants: 45

Gender: female (n=30); male (n=15)

Educational level: above high school

Age: 20-25 years old (n=25) ; above 25 years old (n=20)

Questions

- What wounds are you most likely to have?
- How it is usually be treated?
- How often do you pay attention to the changes in the wound ?
- Will you search online or download software?
- Have you ever had severe trauma?
- How did you treat it?
- What are the general questions for wounds?
- Do you carry coins with you?
- How often do you bring a phone charger with you when you go out?
- What is your phone model?

Conclusions

Measurement tool

- Few people bring coins and chargers with them all the time

Suggested Features (user's need for this app):

1. Compare to new wounds, they more care about the healing condition of old wounds or continuous follow-up
2. Medication instructions
3. Anticipated time or timeline
4. Prevent the wound
5. Get rid of the scar
6. Skin allergy (treatment)
7. How to go to the nearby available hospital that covered medical insurance fee
8. Some of them don't want to take pictures, they prefer to select similar pictures and make comparisons by themselves
9. Most of them don't need wound identification functions, because they know how causes of wounds
10. Want to know what kind of other symptoms will be infected
11. How to treat my wounds if I use the wrong way to treat them at the beginning
12. Want to know more about invisible diagnosis

Diabetics:

1. Have great demand for reminder functions—— their nerves are insensitive so that they will get hurt unconsciously
2. Want to know more about invisible diagnosis
3. Based on wounds, the app can provide more information about their condition
4. Long-term tracking function
5. Provide diabetics with educational resources on wound care, including information on how to prevent and manage wounds

Interview - Version 2 (Old Wound)

Based on the survey we made, we found that the needs for old wounds are more urgent than the new wounds, so we decided to change the purpose and conduct a second survey about the new wound.

Demographic Information

Number of participants: 45

Gender: Female (n=30); male (n=15)

Educational level: Above the high school

Age: Age: 20-25 years old (n=25); above 25 years old (n=20)

Assumptions

1. Users who have failed to treat the wounds by themselves, want to know why is their wound(s) not cured or getting better.
2. Users who have failed to treat the wounds by themselves, and want to know how to cure them.
3. Users who have scars and want to get rid of them.
4. Users who have a chronic wound(s) try to avoid infection and inflammation-diabetics, and users of old age.

Objects

We aim to find out what common problems users have when they treat the wound(s) by themselves and what demands they need after treating wound(s) inappropriately.

Questions

- How long does it take for a wound to heal?
- When do you think you need to search the information about the wound or go to the hospital
- If your wound fails to be cured in time, what would you do?
- What support do you want to receive during your healing time?
- What kind of questions do you always ask about your old wound (scar? inflammation?)
- Where do you get the information on wound treatment?
- How many problems do you think the suggestion part addressed?

Conclusions

Function:

1. It's better to have the function of guidance of medication.
2. Details of why the system recommends this medicine to me.
3. I want to have a diverse combination of medications that I can choose.
4. I can't find a big difference compared to google research.
5. I want to have an online service, or simulated human service so as to enhance credibility. like you can list out the keywords I need to mention in the beginning, then I can type the content by myself. and the keywords will be extracted and analyzed by an AI system. So that many unnecessary steps can be omitted.
6. Typing long sentences is inconvenient, the voice input function is needed.

Experience

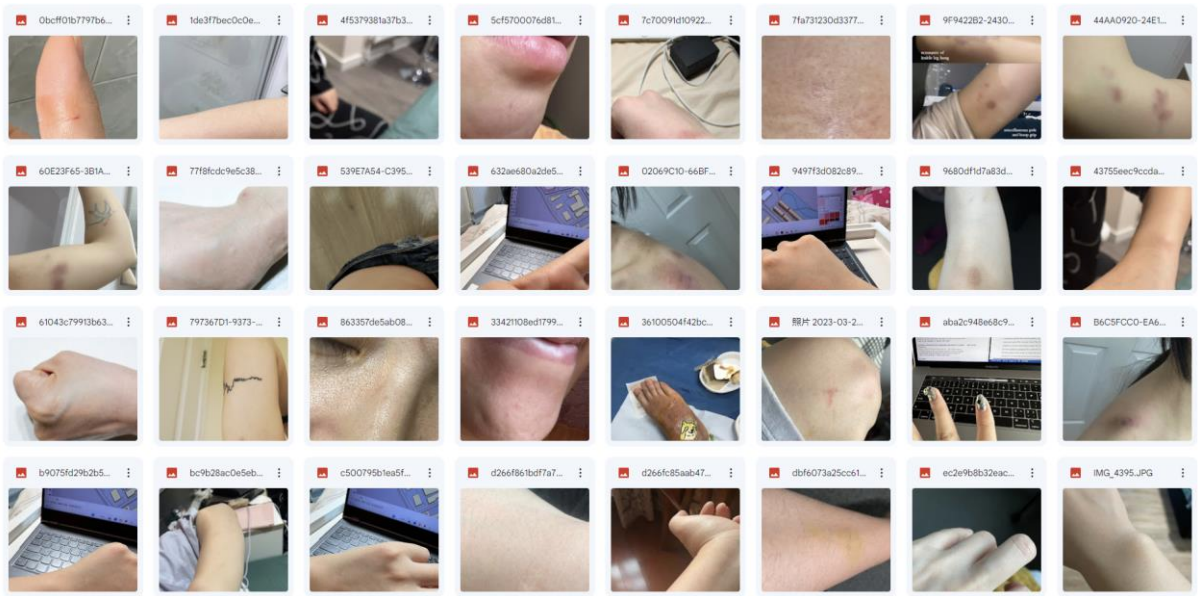
1. Poor experience. merely the standardized questions fail to convince me that the app truly takes all of my conditions into consideration. Diagnosis is not a standardized thing; the whole process overlooks too many personal conditions.
2. The result that the system gives is too general.
3. The way of information collection lack of credibility.
4. Your design should consider the psychological condition of patients.

Process

1. Lacking freedom. I have to follow the whole process and then get a result.
2. Several functions lack logic and connection.

Approaches to Wound Photography by Individuals

Short research has been conducted to understand people's imaging habits and trends. This research was helpful for us to understand the variables involved with general users of the application taking pictures for the application to evaluate.



Here are some of the key findings from the short research:

- Mainly distributed in the extremities
- 15% people like to shoot close up and record details – 5~7 centimeters
- 75% prefer to retain the full picture – above 15 centimeters
- All pictures are taken at indoor places
- People will actively look for a good light place to shoot

- 90% of pictures are vertical angle shot
- The main shooting light source is sunlight and incandescent lamps
- For medium-sized wounds, they posted the camera positioning at a distance of about 1-2 feet from the wound, and multiple pictures were taken from different angles to fully capture the extent of the injury
- For large wounds, the camera was positioned at a greater distance of 2-3 feet

Suggested Data Collection

Classification

- Wound type and size
- Location of the wound
- Depth of the wound
- Presence of foreign objects
- Infection risk
- Patient's age and overall health
- Nutritional status
- Chronic health conditions such as diabetes or peripheral artery disease
- Medications that can interfere with wound healing
- Smoking or tobacco use
- Obesity
- Excessive alcohol consumption
- Poor wound care or dressing changes
- Stress and mental health status

Before the suggestion. the information that needs to be collected:

- Daily activity habits
- Overall physical health condition
- Weather
- Dressing habits
- Eating habits

General Suggestions for the Wound

- **Weather:** humid/dry
- **Dietary habits:** age, nutritional status,
- **Dressing recommendation:** The texture of the cloth can impact the amount of friction and pressure on the wound, which can interfere with the healing process. It is important to choose clothing that is gentle on the wound and does not cause irritation or pressure. Loose-fitting clothing is usually recommended to reduce friction and pressure on the wound site. Your doctor or wound care specialist can provide guidance on appropriate clothing options for your specific wound.

Medication guidance:

- **Stress and mental health status**
- **Unhealthy habits:** Alcohol, smoking, or tobacco use
- **Daily hygiene habits**
- **Number of daily drug changes**
- **Daily Precautions**: Immersing the wound in water, Picking or scratching the wound, Protect the wound from the sun

Medication instructions in different healing stages：

During the initial stage of wound healing, the focus is on preventing infection and promoting blood clotting. Antibiotics and antiseptics may be used to prevent infection, and dressings may be applied to promote clotting and protect the wound.

During the inflammatory stage of wound healing, the focus is on controlling inflammation and preventing further damage to the tissues. Non-steroidal anti-inflammatory drugs (NSAIDs) or other pain medications may be used to control pain and inflammation.

During the proliferation stage of wound healing, the focus is on promoting the growth of new tissue and blood vessels. Medications such as growth factors or collagen-based products may be used to promote tissue growth and accelerate healing.

During the maturation stage of wound healing, the focus is on strengthening and remodelling the newly formed tissue. Medications such as silicone sheets or gels may be used to reduce scarring and improve the appearance of the wound.

Rest duration recommendation

Rest time recommendation: Lack of sleep can weaken the immune system and interfere with the healing process.

How to treat your wound when you take a shower: Cover the wound: Cover the wound with a waterproof dressing or plastic wrap to keep it dry. You can also use waterproof adhesive tape to secure the dressing.

- **Be gentle:** Avoid scrubbing the wound or using a rough sponge or washcloth. Use gentle movements and avoid applying pressure to the wound.
- **Use mild soap:** Use mild soap to clean the surrounding skin, but avoid getting soap on the wound itself.

- **Rinse thoroughly:** Rinse the area thoroughly with warm water to remove any soap or debris.
- **Pat dry:** Gently pat the wound and surrounding skin dry with a clean towel. Do not rub the area or use a hair dryer to dry the wound.
- **Change the dressing:** After showering, check the dressing to ensure it is still secure and dry. If it has become wet or damaged, replace it with a new, dry dressing.

Suggestions for Laceration

Different Locations

Lacerations on the face: Facial wounds are common and can be treated with a gentle cleanser and antibiotic ointment. If the wound is deep, your healthcare provider may use stitches or adhesive strips to close the wound and promote healing. Be careful not to disrupt the wound while it is healing, and protect it from sunlight.

Lacerations on the hands or feet: Wounds on the hands or feet are at risk of infection due to their frequent contact with surfaces. To treat these wounds, clean the area with a gentle cleanser and apply an antibiotic ointment. Cover the wound with a sterile bandage and avoid putting pressure on the area. If the wound is deep or located in a joint, seek medical attention.

Lacerations on the torso: Wounds on the torso can be treated similarly to wounds on the face. Clean the area with a gentle cleanser and apply an antibiotic ointment. Cover the wound with a sterile bandage and avoid tight clothing or anything that may irritate the area. Seek medical attention if the wound is deep or located near vital organs.

Lacerations on the limbs: Wounds on the arms or legs can be treated by cleaning the area with a gentle cleanser and applying an antibiotic ointment. Cover the wound with a sterile bandage and avoid putting pressure on the area. Seek medical attention if the wound is deep or located near a joint.

Lacerations on the scalp: Scalp wounds can be treated with a gentle cleanser and antibiotic ointment. If the wound is deep, your healthcare provider may use stitches or adhesive strips to close the wound and promote healing. Be careful not to disrupt the wound while it is healing, and protect it from sunlight.

Types of Laceration

Linear laceration: This is a straight or slightly curved wound that is usually caused by a sharp object.

Stellate laceration: This is a star-shaped wound that is caused by a blunt object or force.

Perforating laceration: This is a deep wound that passes completely through the skin and underlying tissues.

Avulsion laceration: This is a type of wound where the skin or tissue is partially or completely torn away from the body.

Flap laceration: This is a type of wound where a section of skin or tissue is partially attached to the body, creating a flap-like structure.

Complex laceration: This is a type of wound that involves multiple layers of tissue, such as muscles, tendons, and bones.

Level of Laceration

Severe (deepest/ big size/ locations: head, neck, chest, abdomen, or groin/ Complex lacerations)

Stop the bleeding: Use a clean cloth or bandage to apply firm pressure to the wound to stop bleeding. If the bleeding is severe, apply pressure to an artery above the wound, if possible.

Do not remove any object: Do not attempt to remove any object that may be embedded in the wound, as this can cause further damage and increase the risk of bleeding.

Stabilize the head and neck: If the laceration is in the head or neck area, stabilize the head and neck to prevent movement that could cause further injury.

Monitor the airway and breathing: If the laceration is in the neck or chest area, monitor the airway and breathing. If the person is having difficulty breathing, call for emergency medical help immediately.

Cover the wound: Cover the wound with a sterile bandage or dressing to protect it from further injury or infection.

Different stages of laceration treatment

First stage - Acute phase (0-3 days): The focus during this stage is on stopping bleeding and preventing infection. Treatment may include:

Applying direct pressure to the wound to stop bleeding

Cleaning the wound with saline solution or gentle soap and water

Applying an antibiotic ointment

Covering the wound with a sterile bandage or dressing

Second stage - Proliferation phase (3-14 days): The focus during this stage is on promoting healing and reducing inflammation. Treatment may include:

Continuing to keep the wound clean and covered

Applying warm compresses to reduce swelling and promote circulation

Taking pain medication as prescribed by a healthcare provider

Eating a healthy diet and staying hydrated to support the healing process

Third stage - Remodeling phase (14 days to 2 years): The focus during this stage is on reducing the appearance of scars and restoring normal function to the affected area. Treatment may include:

Applying silicone gel or sheeting to reduce the appearance of scars

Massaging the area around the wound to promote healing and reduce scar tissue

Doing physical therapy exercises to restore strength and mobility to the affected area

Avoiding smoking and exposure to sunlight to reduce the risk of scarring

General suggestions

Picking or scratching at the wound: Picking or scratching at the wound can increase the risk of infection and delay healing. It is important to leave the wound alone and allow it to heal naturally.

Applying excessive pressure to the wound: Applying excessive pressure to the wound can cause it to reopen or delay healing. This includes activities such as kneeling or sitting on the affected area, carrying heavy objects, or wearing tight clothing or shoes that can irritate the wound.

Exposing the wound to sunlight: Sunlight can cause the wound to darken and delay healing. It is important to keep the wound covered or shaded from sunlight until it has fully healed.

Eat a healthy diet. Good nutrition is important for wound care because it helps regulate your blood sugar and assures that you get the vitamins and minerals your body needs to heal, said Christine Olson, RD, LD, CDE, a dietitian at the Harold Hamm Diabetes Center. It's especially important that you get enough protein, she said. Protein helps repair the skin and other tissue that has been damaged.

Get regular exercise. Exercise can help keep your blood circulating and stimulates blood flow to your legs and feet. However, if you have a sore foot, stay off your feet until it heals.

Eating a healthy diet: A diet rich in nutrients such as vitamins C and E, protein, and zinc can help promote wound healing. Eating a balanced diet that includes plenty of fruits, vegetables, whole grains, and lean proteins can provide the necessary nutrients for healing.

Staying hydrated: Drinking plenty of fluids, particularly water, can help keep the body hydrated and promote healing.

Getting enough sleep: Getting adequate sleep is important for the body to repair and regenerate tissues. Aim for at least 7-8 hours of sleep per night.

Avoiding smoking and alcohol: Smoking and excessive alcohol consumption can impair wound healing by reducing blood flow and impairing the immune system. It is best to avoid these habits during the healing process.

Managing stress: Stress can slow down the healing process by suppressing the immune system. Engaging in relaxation techniques such as meditation, deep breathing, or yoga can help manage stress and promote healing.

Staying active: Regular physical activity can help improve circulation and promote healing. Consult with your healthcare provider regarding the types and frequency of physical activity that are safe for your particular condition.

How to take a shower?

Wait 24-48 hours: It is recommended that you wait 24-48 hours after the injury before taking a shower to allow time for the wound to begin healing.

Cover the wound: Use a waterproof bandage or dressing to cover the wound to prevent it from getting wet during the shower.

Keep the water lukewarm: Use lukewarm water instead of hot water, as hot water can irritate the wound and delay healing.

Be gentle: Avoid scrubbing the wound or using harsh soaps, as this can irritate the wound and delay healing. Use a mild soap and gently wash the area around the wound.

Pat dry: After showering, pat the wound dry with a clean, dry towel. Do not rub the wound, as this can cause irritation.

Change the bandage: After showering, change the bandage or dressing as directed by a healthcare provider.

How to treat the laceration in the summer?

Cover the wound: Use a waterproof bandage or dressing to cover the wound to protect it from the sun, heat, and potential irritants.

Wear loose, breathable clothing: Avoid tight clothing that may rub against the wound and cause irritation. Wear loose, breathable clothing to keep the wound cool and dry.

Stay in shaded areas: Avoid prolonged exposure to direct sunlight, as this can increase the risk of scarring and slow the healing process. Stay in shaded areas or wear a wide-brimmed hat to protect the wound.

Apply sunscreen: If the wound is on an area of skin that cannot be covered with clothing or a bandage, apply a broad-spectrum, water-resistant sunscreen with an SPF of 30 or higher to protect the wound from the sun's harmful rays.

Avoid swimming: Avoid swimming or soaking in hot tubs or pools until the wound is fully healed, as these environments can increase the risk of infection.

Stay hydrated: Drink plenty of fluids to stay hydrated and support the healing process.

Change the dressing regularly: If the wound is in an area where sweat is likely to accumulate, such as the armpit or groin, change the dressing more frequently to keep the wound dry and clean.

Use absorbent materials: If you are sweating a lot, use absorbent materials, such as gauze or cotton, around the wound to help absorb sweat.

Avoid tight clothing: Wear loose, breathable clothing to prevent excess sweating and to allow air to circulate around the wound.

If you get wet

Clean the wound: If the wound gets wet, gently clean it with mild soap and water to remove any dirt or debris. Be careful not to rub or irritate the wound.

Dry the wound: Pat the wound dry with a clean towel or allow it to air dry. Be sure to dry the surrounding skin as well to prevent moisture from getting trapped against the wound.

Apply a new dressing: Once the wound is dry, apply a clean, dry dressing to protect the wound and prevent further moisture from getting in.

Change the dressing regularly: If the wound gets wet frequently, such as in the shower or while swimming, it may be necessary to change the dressing more frequently to keep the wound dry and clean.

Avoid soaking the wound: Avoid activities that may cause the wound to soak in water, such as swimming or taking long baths, until the wound has healed.

Seek medical attention: If the laceration is deep, bleeding heavily, or becomes infected, it is important to seek medical attention from a healthcare provider. They can determine if additional treatment, such as antibiotics or wound care, is necessary.

Dietary

Avoid foods that are high in sugar: High intake of sugar can impair the immune system and slow down the healing process. Limit your intake of sugary foods and drinks such as candy, soda, and pastries.

Avoid foods that are high in saturated and trans fats: These types of fats can increase inflammation in the body and may delay healing. Limit your intake of foods that are high in saturated and trans fats, such as fried foods, processed snacks, and fatty meats.

Increase your intake of fruits and vegetables: Fruits and vegetables are rich in nutrients such as vitamins C and E, which are important for wound healing. Aim for at least 5 servings of fruits and vegetables per day.

Choose lean protein sources: Protein is important for tissue repair and regeneration. Choose lean protein sources such as chicken, fish, beans, and tofu.

Stay hydrated: Drinking plenty of water and other fluids can help keep the body hydrated and promote healing.

Cloth/ Textures (Don'ts)

Tight or restrictive clothing: Tight or restrictive clothing can put pressure on the wound, which can cause discomfort and delay healing. Clothing should be loose-fitting and comfortable to allow for proper blood flow to the affected area.

Synthetic fabrics: Synthetic fabrics such as polyester and nylon can irritate the wound and cause itching or discomfort. Natural fabrics such as cotton and linen are more breathable and less likely to cause irritation.

Rough or scratchy fabrics: Rough or scratchy fabrics such as wool can cause irritation and delay healing. Soft and smooth fabrics such as cotton or silk are less likely to cause irritation and promote healing.

Clothing that rubs against the wound: Clothing that rubs against the wound can delay healing and increase the risk of infection. It is important to choose clothing that is loose-fitting and does not rub against the wound.

Clothing that is difficult to remove: Clothing that is difficult to remove can cause pain or discomfort when changing dressings or cleaning the wound. It is important to choose clothing that is easy to remove and does not require excessive movement or stretching.

Activities

Trenuous exercise: Strenuous exercise can cause the wound to reopen or delay healing. Activities such as running, weightlifting, and contact sports should be avoided until the wound has fully healed.

Swimming or soaking in water: Submerging a wound in water can increase the risk of infection. Swimming, hot tubs, and long baths should be avoided until the wound has fully healed.

Weather

Humid Weather :

Keep the wound dry: Use a clean, dry bandage or dressing to cover the wound and keep it dry. Change the bandage or dressing regularly, especially if it becomes wet or dirty.

Avoid soaking the wound: Avoid soaking the wound in water, such as in a bath or swimming pool, as this can increase the risk of infection.

Use topical antibiotics: Apply a topical antibiotic ointment to the wound to help prevent infection. Be sure to follow the instructions on the package and do not overuse the antibiotic.

Keep the wound moist: Use a sterile, moist bandage or dressing to cover the wound and keep it moist. Change the bandage or dressing regularly, especially if it becomes wet or dirty.

Dry Weather:

Use topical moisturizers: Apply a topical moisturizer or emollient to the skin surrounding the wound to help prevent cracking and keep the skin moisturized.

Stay hydrated: Drink plenty of fluids to stay hydrated and help promote healing.

Use a humidifier: Use a humidifier to keep the air moist and prevent the skin from becoming too dry.

Protect the wound: Cover the wound with clothing or a protective barrier, such as a bandage or dressing, to protect it from further injury or irritation.

Monitor for signs of infection: Watch for signs of infection, such as redness, swelling, or pus. If these symptoms develop, seek medical attention right away.

Prevention of Scarring

Keep the wound clean and moist: Keeping the wound clean and moist can promote healing and minimize scarring. Cover the wound with a sterile bandage or dressing, and change it regularly. Apply an antibiotic ointment as directed by a healthcare provider.

Avoid picking or scratching at the wound: Picking or scratching at the wound can cause scarring or delay healing. It is important to leave the wound alone and allow it to heal naturally.

Avoid exposing the wound to sunlight: Sunlight can darken scars and make them more noticeable. Keep the wound covered or shaded from sunlight until it has fully healed.

Avoid smoking: Smoking can impair blood flow to the wound and delay healing, which can increase the risk of scarring. Avoid smoking and second-hand smoke to promote healing.

Use silicone gel or sheeting: Silicone gel or sheeting can reduce the appearance of scars by providing a protective barrier and helping to flatten and smooth the skin.

Massage the area: Massaging the area around the wound can help break up scar tissue and improve circulation, which can promote healing and reduce scarring.

Apply sunscreen to the wound after it has healed. Sun protection may help reduce red or brown discolouration and help the scar fade faster. Always use broad-spectrum sunscreen with an SPF of 30 or higher and reapply frequently.

Don’t do

Do not attempt to close the wound or remove any objects that may be embedded in the wound. These actions can cause further damage and increase the risk of infection.

Removing embedded objects: If an object, such as glass or metal, is embedded in the wound, do not try to remove it yourself. This can cause further injury and increase the risk of bleeding and infection.

Applying hydrogen peroxide or alcohol: While hydrogen peroxide and alcohol can be effective in killing bacteria, they can also damage healthy tissue and slow down the healing process. It is best to use clean water or saline solution to clean the wound.

Using non-medical substances: Applying non-medical substances, such as butter, oil, or toothpaste, to the wound can do more harm than good. These substances can introduce bacteria and cause an infection.

Chronic Disease

Diabetics:

It might be a good idea for people with diabetes to wear shoes and socks when walking around, especially if a wound has developed. Being barefoot increases the risk of infection.

People with diabetes should seek treatment if a wound develops on their foot and does not heal. A person will often need to take antibiotics to combat any infections, and they might require hospitalization if the wound is severe.

1. Keep the wound clean: Clean the wound gently using mild soap and water. Avoid using harsh chemicals, and make sure to rinse the wound thoroughly to remove any soap residue.
2. Dress the wound appropriately: Use sterile dressings to cover the wound, and change them regularly as directed by your healthcare provider.
3. Manage pain: Chronic wounds can be painful, and it's important to manage the pain effectively to prevent discomfort and anxiety. Consult with your healthcare provider to determine the best pain management strategy for you.
4. Control underlying health conditions: Chronic wounds may be a symptom of an underlying health condition, such as diabetes or circulatory issues. Controlling these conditions can help promote healing and prevent further complications.
5. Eat a balanced diet: Proper nutrition is essential for wound healing. Eating a well-balanced diet rich in protein, vitamins, and minerals can help support the healing process.
6. Get adequate rest: Adequate rest is crucial for healing. Make sure to get enough sleep and avoid activities that may cause further stress or strain on the wound.

Technical Research

Wound Classification with Machine Learning

There is a multitude of different types of wounds that the human body can endure. In the first iteration of wound classification, machine learning algorithms were studied to determine if an image of a wound could be accurately classified. This image would be taken on a mobile device and would undergo analysis while in the Woundification application.

The development of a machine learning model would be heavily dependent on a large, labeled, and accurate wound image database. Access to the most accurate database from the Silesian University of Technology in Poland could not be obtained, and many other databases were not available for public use (https://www.nature.com/articles/s41598-022-21813-0#data-availability). Additionally, the University of British Columbia in Canada was contacted to determine if access to their private wound image database could be used; however, the images at hand were on rat subjects instead of humans. This would greatly alter the result of wound classification if this database was used instead.

There were also difficulties in developing this model in-house. Given the complexity (i.e., use of neural networks) of these algorithms, an in-depth understanding of deep learning architecture would be necessary. With the limited understanding of these algorithms, developing a machine-learning model to detect wounds would prove to be not feasible.

Reference

- Anisuzzaman, D.M., Patel, Y., Rostami, B. et al. Multi-modal wound classification using wound image and location by deep neural network. Sci Rep 12, 20057 (2022). https://doi.org/10.1038/s41598-022-21813-0

Wound Identification with OpenCV and HSV Color Scale Analysis

As an alternative method to identifying whether an image is a wound, an algorithm which analyzes the colours of an image was implemented. This method converts an image from its original BGR (blue, green, red) colour space to an HSV (hue, saturation, value) colour space. The HSV colour space provides more accuracy when detecting colours and processing digital graphics (Rastogi, 2022).

In this algorithm, bitwise operations are performed on an image to extract a range of red colours to identify the wound. This allows us to extract an irregular-shaped wound object from an image. The red wound is isolated from the original image and a blue box surrounding the image appears.

Figure 9: Algorithm clearly identifies wound and separates colour from photo

Figure 10: Wound analysis is incorrect due to the colour of the skin tone

However, this algorithm runs into issues when the quality of the image is poor, when the skin-tone of the original user has a pink or red hue, and when the image is of darker skin tones. It is unable to calculate the correct colour analysis and results in identifying the wrong area of concern.

Due to the inconsistencies and lack of accuracy found with this algorithm, this method of wound identification could not be used in the Woundification application, and the level of sophistication that this algorithm has is too low to determine if a wound is present when presented with a photo.

Reference

- Wound Identification with OpenCV and HSV Colour Scale Analysis https://github.com/pandyah5/WoundSensor/blob/master/main_script.py
- Rastogi, A. 2022 Jan 18. Color Spaces in OpenCV [blog]. [accessed 2023 Mar 23]. https://blog.devgenius.io/color-spaces-in-opencv-f0cd3e1d3fab.

Colour Patch Method for Automatically Calculating Wound sizes

A few research papers have been explored to understand the studies done in automatically calculating wound sizes. The colour patch method is one of the prominent ones. It is possible to measure wound size and how it changes over time using a colour patch to a fairly accurate degree.

Reference:

- Yang, Sejung, et al. “Sequential Change of Wound Calculated by Image Analysis Using a Color Patch Method during a Secondary Intention Healing - PMC.” *Plos One*, 20 Sept. 2016, https://doi.org/10.1371/journal.pone.0163092.

Wound Depth Perception

The initial idea for implementing wound image depth perception in a limited time is by exploring different pre-trained machine-learning models in various libraries. A few libraries we looked into are Tensorflow, PyTorch, Keras, MXNet, and others. Tensorflow library, for its flexibility and ease of use, was picked to implement pre-trained models for depth perception.

Reference:

- The TensorFlow library version used is 2.4.0, imported from https://cdn.jsdelivr.net/npm/@tensorflow/tfjs@2.4.0/dist/tf.min.js
- The pre-trained model developed by intel and hosted on TensorFlow used in the project is midas/v2, imported from https://tfhub.dev/intel/midas/v2/2.

This particular model is for Monocular Depth Estimation. Monocular Depth Estimation is the process of predicting the depth map of a scene using only a single RGB image as input. It is a fundamental task in computer vision and has various applications such as virtual and augmented reality, autonomous driving, robotics, and more.

Why pick this model for wound depth perception?

In wound depth perception, the model can be used to estimate the depth of a wound from a photograph of the wound. The model takes the RGB image as input and produces a corresponding depth map as output, which represents the estimated depth of the wound at each pixel in the image. The depth map produced by the model can be used to identify the depth and extent of the wound, which is important for determining the appropriate treatment and care plan.

For example, a deep wound may require more aggressive treatment or surgical intervention than a shallow wound.

Development Summary:

The depth perception code loads an image of a wound, preprocesses it, uses the above pre-trained model to estimate the depth of the wound, and calculates the average depth of the wound. This code can be used to automate the process of wound depth estimation, making it faster and more efficient.

Image used for depth perception:

Problems encountered:

1. CORS error: To use the midas/v2 pre-trained model, CORS (Cross-Origin Resource Sharing) must be enabled. If not, the model will not load. Quick fix: used the following command to enable CORS and start the local server to avoid CORS and model loading-related errors.

```
http-server --cors
```

2. Model compatibility error: The model had a .pb extension (saved_model.pb) when downloaded locally. Support for .pb models has been removed in the latest versions of TensorFlow.js to support the use of .json models. Fix: used the following command to convert the saved_model.pb to model.json. This converted json model is used in the code.

```
tensorflowjs_converter --input_format=tf_saved_model --
output_format=tfjs_graph_model ./saved_model_path
./model.json
```

3. Tensor dimension error: "The shape of dict['0'] provided in model.execute(dict) must be [1,3,384,384], but was [1,384,3,384]" on the console. There are some issues in transposing the input and output tensors. Resizing the input tensor isn't fixing this issue.

Time allocation:

Two-three weeks went into the work of implementing the wound depth perception feature. Currently, the model is facing issues with the preprocessed input and output image dimensions. Nevertheless, with additional time and further code research, these issues can be resolved, allowing the code to be fully functional for enabling accurate wound depth perception.

Conclusion and Discussion

Various factors, including political, economic, sociocultural, technological, environmental, and legal, may impact the development, adoption, and use of wound care technologies in Canada, particularly in British Columbia, where there is consistent financial support for long-term home and community care and a significat potential wound care market.

To have a clear product value proposition, **Woundification could be an app connecting people to education for treatment options, reminders for reassessment, and directing people to seek medical care when appropriate.** This solution primarily assists middle-aged, elderly individuals with minor and old wounds in improving their quality of life by addressing their true medical and cosmetic needs. It also reduces the difficulty in developing a labeled wound image database and technology for camera assessment.

Higher education levels and those who are comfortable with technology are more inclined to use wound management apps as they are seeking rather relevant, detailed, professional, and trustworthy suggestions for healing.

Based on different evaluation standards, wounds could be classified into different types of wounds and each type of wound contains a huge image database and parameters that affect the non-medical suggestions. Therefore, **consider the context of a specific wound(such as a laceration) that as a starting point of development to explore the feasibility of the application.**

Considering theoretical and practical experience, the questionnaire for generating non-medical suggestions could follow this pattern:

- Warning of bleeding, foreign objects, and severe pain
- Choose the location
- Recognize and calculate the wound size and wound type
- Mechanism
- Bleeding condition
- Laceration wound edges
- Medical conditions
- Medicine used
- Symptoms
- Wound history
- Exudate condition
- Skin Allergies
- Tetanus

Our study shows that optimal wound photos are taken from more than 15 cm away, indoors, with good lighting, and using vertical angle shots. Developers of wound care apps can consider these preferred camera angles, lighting sources, and distance when designing the app's image capture user interface to ensure optimal image quality and user experience.

Healthcare professionals can use this information to guide patients on capturing useful wound images for remote monitoring and care.

Consider external technical and business cooperation to reduce the technical barriers in the future. For instance, providing users with relevant suggestions through accessing chatGPT may be one of the means to solve the problem of insufficient suggestions.