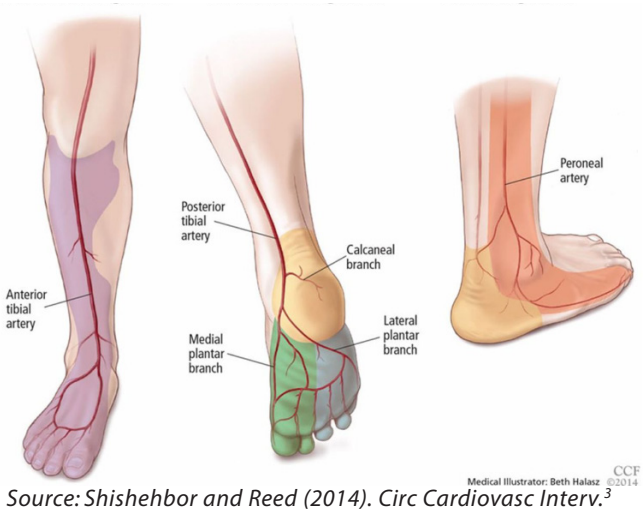
MIMOSA Diagnostics Sponsored Learning:

Shining a Light on Tissue Health: Canadian Leadership

Presenters: Dr. Karen Cross MD PhD FRCSC, Tracey Rickards BN RN MN PhD, Dr. Jordan Tarshis MD FRCPC DRCPC and Ronni Bellefontaine CCRN

The Concept Of Angiosomes

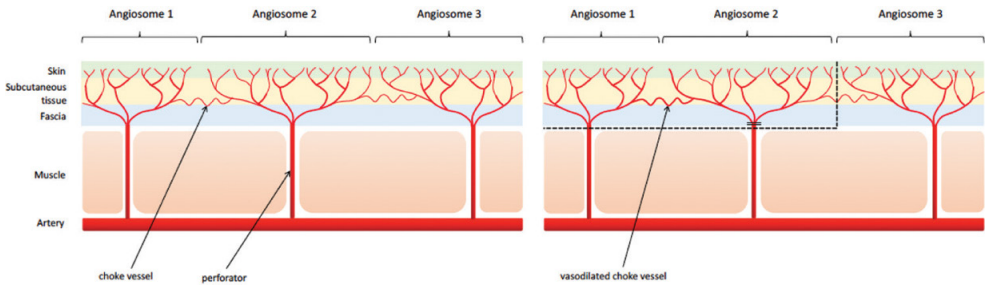
An angiosome is defined as a block of tissue (i.e., skin, muscle, tendon, and/or bone) supplied by a particular course of arteries.[1] There are connections between angiosomes known as choke arteries.[1] These connections provide safety conduits to enable blood flow between border zones if the source artery in a particular angiosome is injured.[1] There are six angiosomes in the foot and ankle supplied by three main arteries (i.e., posterior tibial artery, anterior tibial artery and peroneal artery). Understanding of angiosome is crucial in surgical planning, particularly in revascularization and patient outcomes. Fifteen percent of ischemic lower extremity wounds fail to heal despite adequate arterial bypass surgeries.[2] A direct revascularization approach is preferred over an indirect approach. Direct revascularization is when the bypassed vessel directly feed the source artery of the angiosome where the wound is.[2] The failure rate and amputation rate are much lower when the revascularization is direct.[2]



Source: Shishehbor and Reed (2014). Circ Cardiovasc Interv.[3]

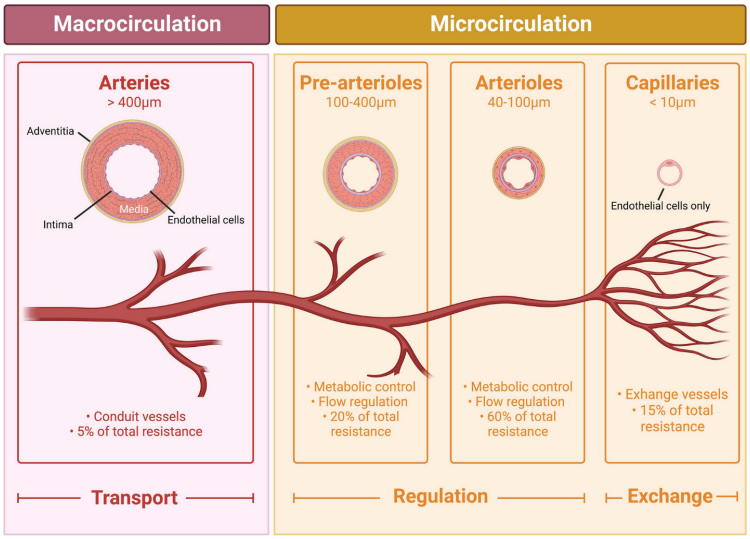
Macrocirculation, Microcirculation And Wound Healing:

Adequate perfusion is crucial for proper and timely wound healing. The macrocirculation (i.e., arteries) are responsible for bringing oxygenated blood from the heart to the microcirculation. The microcirculation (e.g., pre-arterioles, arterioles and capillaries) then deliver oxygenated blood to the skin and the wound bed. Compromised macro- and microcirculation delay wound healing, rendering them chronic or non-healable. Over the past 20 years, advances in research have recognized and emphasized the importance of



Source: Eccles et al. (2020). Standards for the Management of Open Fractures[1]

not just microcirculation, but microcirculation in wound healing.



Source: Merdji H et al. (2023). Ann Intensive Care.[4]

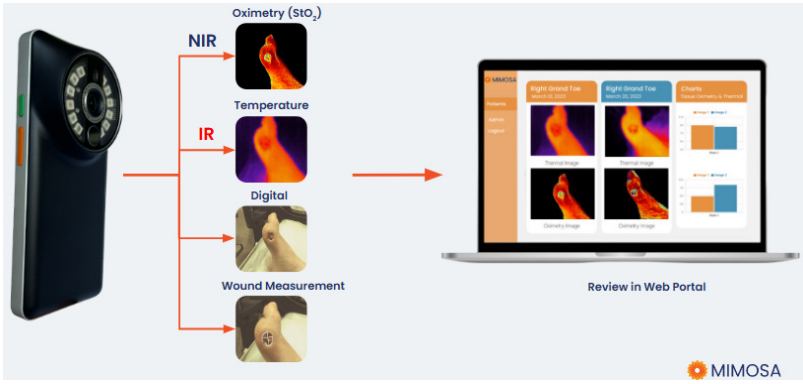
Macro- and microcirculation can be assessed by two broad categories of vascular imaging – optical and non-optical. Optical imaging involves light-based technologies, whereas non-optical imaging does not. Table 1 summarizes the common optical and non-optical imaging techniques for the assessment of macro- and microcirculation.

Table 1. Imaging Techniques for the Assessment of Macro- and Microcirculation

		Microcirculation
Optical Imaging	Doppler (Duplex) Ultrasound Angiography	Laser Doppler Flowmetry (LDF) Near-Infrared Spectroscopy (NIRS)
Non-Optical Imaging	Ankle-Brachial Index (ABI) Pulse Volume Recording (PVR)	Transcutaneous Oximetry ($TcPO_2$) Skin Perfusion Pressure (SPP)

MIMOSA Pro

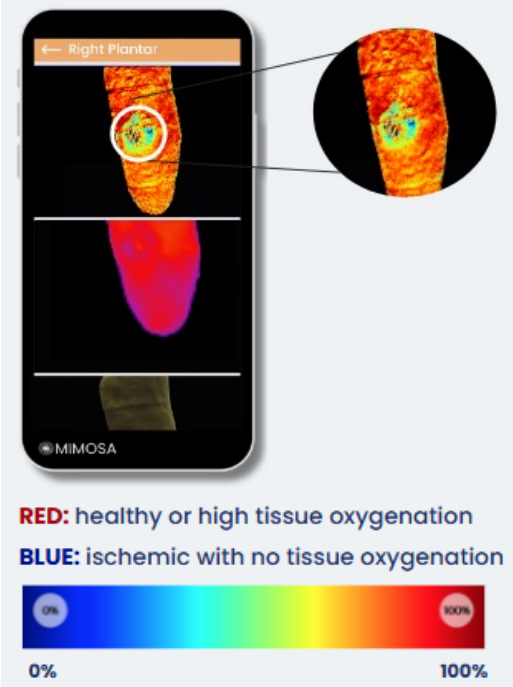
The MIMOSA Pro is an FDA-approved (and recently Health Canada-approved) pocket-sized medical device that enhances clinical decision-making in wound care. MIMOSA Pro provides four key functionalities available at the point of care: near infrared spectroscopy (NIRS), infrared spectroscopy (IR), digital wound photography and wound measurement. MIMOSA Pro is smart and agile – wound images and data are stored and can be viewed on a web portal.

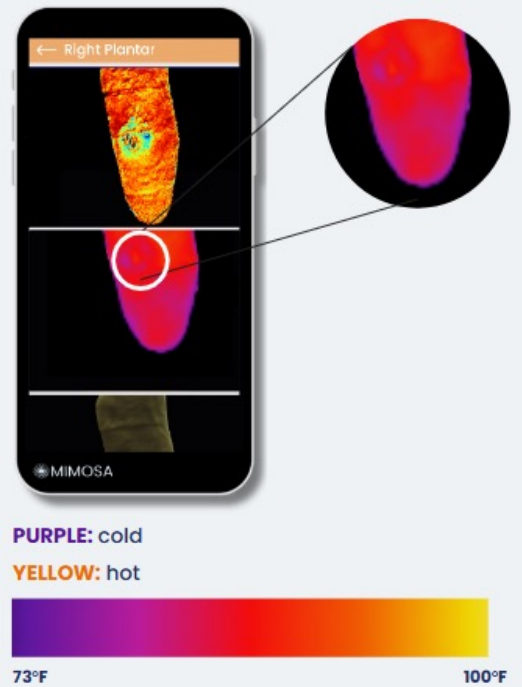


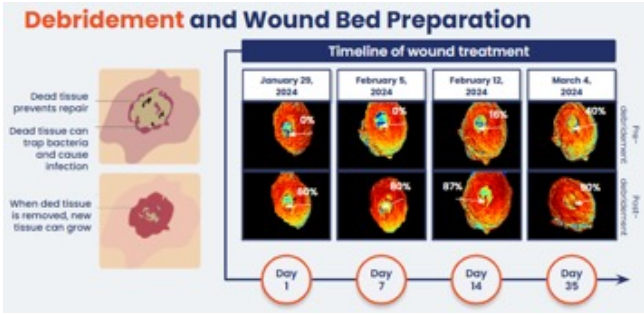
NIRS a fibre-based technology that is commonly used in health care (e.g., pulse oximeter) and provides information beyond what the naked eye can see. The light emitted by the MIMOSA Pro goes below the surface of the skin and is absorbed by the hemoglobin in red blood cells. The light that is not absorbed will bounce back and the signals are detected by the camera system. This creates a digital fingerprint – a surrogate marker for tissue oxygenation (StO_2). Clinicians can visualize wound and peri-wound tissue oxygenation at the point of care. It provides information on healing trajectories and enables clinical decision-making (e.g., debridement, pre- and post-intervention evaluation). Skin temperature is an important clinical indicator for wound infection and inflammatory conditions (e.g., Charcot neuroarthropathy). Through the integrated infrared spectroscopy (IR), clinicians can assess temperature variations in and round the wound. Clinicians can also capture digital images of the wound at point of care. MIMOSA Pro can also provide wound measurements. These features simplify and improve the accuracy of documentation. This also enables clinicians to track wound healing progression.

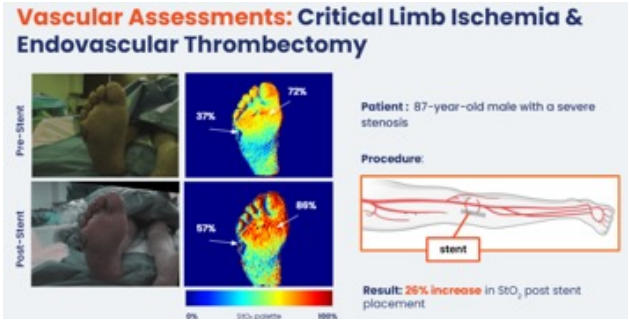
Clinicians can utilize MIMOSA Pro to guide wound bed preparation. For example, NIRS imaging provides real-time feedback and offers insights to the efficacy of debridement. Clinicians can also use MIMOSA Pro to instantly assess the

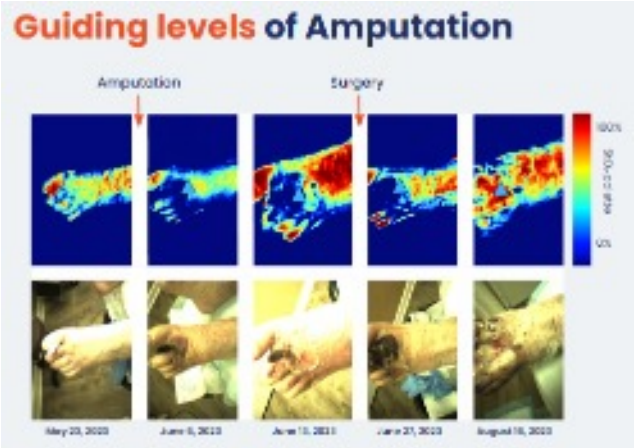
effectiveness of invasive vascular procedures at the bedside. Surgeons can utilize MIMOSA Pro to guide surgical decision (e.g., level of amputation) and predict post-operative necrosis and flap failure.

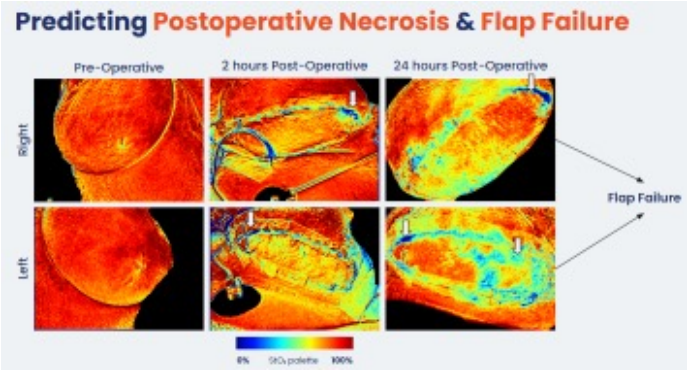










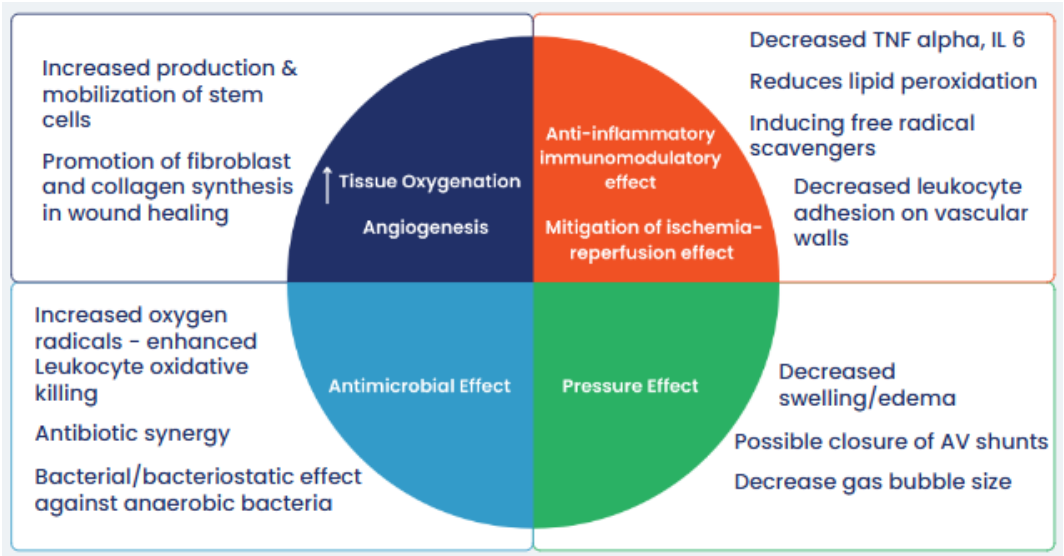


The Value Of Imaging In Hyperbaric Oxygen Therapy (HBOT)

Hyperbaric oxygen therapy (HBOT) is the delivery of high concentrations of oxygen at pressures significantly higher than ambient air. HBOT is indicated for deep infections (i.e., osteomyelitis, acute ischemia, compromised surgical flaps and grafts, and complex non-healing wounds. While it is an adjunctive therapy, HBOT does not replace good wound care. There are, however, many benefits to HBOT in wound healing, some of which are highlighted in Figure 1

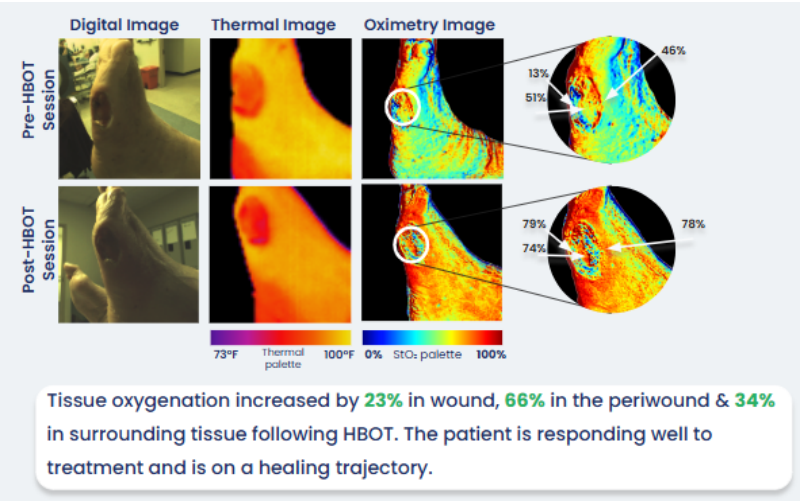
A common misconception about HBOT is that the effects are temporary (i.e., only when the patient is in the hyperbaric chamber). The human body responds to hypoxia by producing hypoxia-inducible factor-1-alpha (HIF-1-alpha). When the patient steps out of the hyperbaric chamber and breathes ambient air, the body is 'tricked' by thinking it is in a hypoxic state and subsequently releases HIF-1-alpha. This is how HBOT provides the short-term and prolonged effects beneficial to wound healing stated above.

Figure 1. The Benefits of Hyperbaric Oxygen Therapy



The following is an example of a patient with a diabetic foot ulcer (DFU) receiving HBOT to enhance healing. Wound images were taken pre- and post-HBOT using the MIMOSA Pro.

The use of MIMOSA Pro not only provided a digital image of the wound, but valuable information such as real-time qualitative validation of HBOT as evidenced by increased in wound and peri-wound oxygenation. These types of objective visualizations may enhance patient adherence and allows for more accurate documentation. They also allow clinicians to track progression and project healing, especially pre- and post-intervention. They can also aid in streamlining clinical decision making, including when to discontinue a particular treatment (e.g., HBOT).



Innovative Approaches to Wound Care Across Canada

New Brunswick – The Healthy Seniors Pilot Project

The median age in New Brunswick is 45.7 years, the second highest in Canada. Approximately 22.8% New Brunswickers are 65 years or old – 27% of them live alone and 10% are living in poverty. Forty-seven percent of those who are 65 years or older live in a rural/remote area. Individuals living in rural/remote areas have a three to four times higher chance of amputation due to delayed access to care. Diabetes contributes to 70% of non-traumatic leg and foot amputations. Approximately 85% of these were preceded by a diabetic foot ulcer (DFU). More importantly, 80% of lower extremity amputations (LEA) related to diabetic foot complications can be prevented with the integration of prevention and interdisciplinary

care.

The *Healthy Seniors Pilot Project* was a partnership between the University of New Brunswick and the Horizon Health Network. The project aimed to gain a better understanding of the needs of seniors wanting to age in place/at home; improve diabetic foot health among isolated seniors; and reduce self-reported loneliness and social isolation. The project included six foot risk assessment and foot care visits (every four to six weeks) by registered nurses (RNs). MIMOSA Pro was used for foot and wound monitoring and to aid clinical decision-making. Registered social worker (RSWs) provided baseline and periodic patient assessments and information about accessing health care resources. The interdisciplinary team also included, but not limited to, dietitians and occupational therapists.

A total of 313 seniors completed all of the foot assessment and care visits – 53.8% of them were at a high or urgent risk based on diabetic foot risk scores and 6% had an active ulcer.[5] On average, the foot risk scores decreased after three visits compared to baseline.[5] The patients' mental health also improved – anxiety and depression scores decreased significantly after 3 months compared to baseline.[5] This pilot project demonstrated the importance of early intervention and patient engagement. It also highlighted the importance of collaborative efforts to achieve better patient outcomes.

Nova Scotia – The Wound Innovation Collaborative

The Nova Scotia Health Innovation Hub is part of the Nova Scotia Health Authority. They bring technology and solutions into the health-care system through industry partnerships. They also support clinicians in search of health technology solutions or are on a quest to create their own. The *Wound Innovation Collaborative* (*WIC*) aims to improve patient outcomes by empowering communities with the tools and knowledge to deliver equitable wound care. Their projects are founded on four strategic pillars embedded in its vision: 1) Annotated meaningful data; 2) Impactful products and partnerships; 3) Knowledge translation and integration; 4) Community connection.

One of *WIC*'s projects is to create a provincial wound registry. This will serve as a data collection platform for wounds across Nova Scotia. The goal of this project is for clinicians to have access to this database, leading to better patient outcomes (e.g., more personalized care, faster rate of healing). The *WIC* also creates partnerships with companies like MIMOSA Diagnostics to bring the latest wound care innovations to Nova Scotians and ensure optimal care for all. Clinicians (i.e., NSWOCs) in the Central Zone of the Nova Scotian Health Authority will be the first to be trained to utilize and implement MIMOSA Pro in the management of complex wounds.

The *WIC* strives to support clinical nurse educators in wound care. They ensure alignment and collaboration on initiatives with Interprofessional Practice & Learning (IPP&L) colleagues within the provincial wound care program. They also support the implementation of new roles in wound care, including the wound care clinical nurse educators and pressure injury support nurses. These roles are integral to knowledge translation and integration in the front lines within the health system. Lastly, *WIC* aims to bridge the gap between hospital and community wound care to ensure a seamless transition of care to achieve better patient outcomes. This is accomplished through building new and strengthening existing community partnerships. Afterall, majority of wound care is practiced in the community and collaboration is the key to achieving optimal patient outcomes.

Dr. Karen Cross MD PhD FRCSC is a Plastic & Reconstructive Surgeon and PhD Scientist. Dr. Cross leads the *Wound Innovation Collaborative*, a centre of excellence in wound innovation and the data registry for the province of Nova Scotia. As an Innovator in Residence at the Nova Scotia Innovation Hub. She was recently named one of Atlantic Canada's Top 50 CEOs of the Year, Innovator of the Year in 2024, and one of Canada's Top 14 Entrepreneurs to Watch in 2023.

Tracey Rickards BN RN MN PhD was an Assistant Professor in the Faculty of Nursing at

the University of New Brunswick in Fredericton. She completed her Bachelor of Nursing at UNB in 1986, her Master of Nursing at UNB in 2005, and her PhD in Nursing at Dalhousie University in 2013.

Dr. Jordan Tarshis MD FRCPC DRCPC obtained his Doctor of Medicine degree at McMaster University and completed his residency in anaesthesiology at the University of Toronto. He is on staff at Sunnybrook Health Sciences Centre. Dr. Tarshis is a Diplomate of the Royal College of Physicians and Surgeons of Canada after completing the Area of Focused Competence in Hyperbaric Medicine at the University of Toronto. He currently practices hyperbaric medicine at Restore Hyperbaric Oxygen and Medical Centre in Mississauga, Ontario when not practicing clinical anaesthesia.

Ronni Bellefontaine CCRN is the Clinical Manager, Innovation at Nova Scotia Health. She started out her career in cardiac care nursing, before transitioning to the Health Innovation Hub to use her skills and education to impact patients in another way.

References

1. Eccles, Simon, and others (eds), Standards for the Management of Open Fractures (Oxford, 2020; online edn, Oxford Academic, 1 Aug. 2020), https://doi.org/10.1093/med/9780198849360.001.0001
2. Attinger CE, Evans KK, Bulan E, Blume P, Cooper P. Angiosomes of the foot and ankle and clinical implications for limb salvage: reconstruction, incisions, and revascularization. Plast Reconstr Surg. 2006 Jun;117(7 Suppl):261S-293S. doi: 10.1097/01.prs.0000222582.84385.54. PMID: 16799395.
3. Shishehbor MH, Reed GW. Personalized approach to revascularization of critical limb ischemia. Circ Cardiovasc Interv. 2014 Oct;7(5):642-4. doi: 10.1161/CIRCINTERVENTIONS.114.001923. PMID: 25336603.
4. Merdji H, Levy B, Jung C, Ince C, Siegemund M, Meziani F. Microcirculatory dysfunction in cardiogenic shock. Ann Intensive Care. 2023 May 6;13(1):38. doi: 10.1186/s13613-023-01130-z. PMID: 37148451; PMCID: PMC10164225.
5. Rickards T, Roberts C, Smith T, Shittu S, Boodoo C, Cross K. Using Near-Infrared Spectroscopy and Education to Support Older Adults with Diabetic Foot Ulcers to Age-in-Place: A Case Series. Adv Skin Wound Care. 2024 Aug 1;37(8):422-428. doi: 10.1097/ASW.0000000000000146. PMID: 39037096.

MIMOSA

Presentation Digest is a production of Wounds Canada.

We are celebrating our 30th year

SAVE THE DATE

2025 WOUNDS CANADA NATIONAL CONFERENCE

Toronto, Ontario | The Westin Harbour Castle | October 2-4, 2025

WoundsCANADA.ca

For more information contact:
info@woundscanada.ca

Find us on social media: @WoundsCanada

Photo courtesy:
Bruin Biometrics LLC

A Pressure Injury Prevention (PIP) Quality Improvement Pilot Of Sub-Epidermal Moisture Scanning In Acute Care

By Marlene Varga MSc BScN, Misha Jado BScN, Sebastien Normandin BHK ARJO and Jacqueline Brayshaw BN RN

How to cite: Varga M, Jadoo M, Normandin S, Brayshaw J. A pressure injury prevention (PIP) quality improvement pilot of sub-epidermal moisture scanning in acute care. Wound Care Canada. 2024;22(2): pg # to come. DOI: 10.56885/ZDJE4034

Introduction

A pressure injury is defined as localized damage to the skin and/or underlying tissue, due to pressure or pressure in combination with shear.[1] Patients with activity/mobility impairment are at highest risk due to their inability to safely reposition or mobilize themselves, leaving them exposed to prolonged unrelieved pressure and/or shear.[2,3] In Canada, the prevalence of pressure injuries is 26% with 25.1% acute care, 29.9% non-

acute care, 22.1% mixed health-care settings and 15.1% in community care settings.[4] Hospital-acquired pressure injury treatment costs range from $44,000 for Stage 2 to $90,000 for Stage 4.[5] The cost to treat pressure injuries is substantially higher than prevention.[6,7] The burden on those living with pressure injuries[8] and those engaged in efforts to prevent and treat them is enormous.[9] While a zero-pressure injury rate is desirable, it also is very unlikely,[10] however there is consensus that most pressure injuries are preventable.[11]

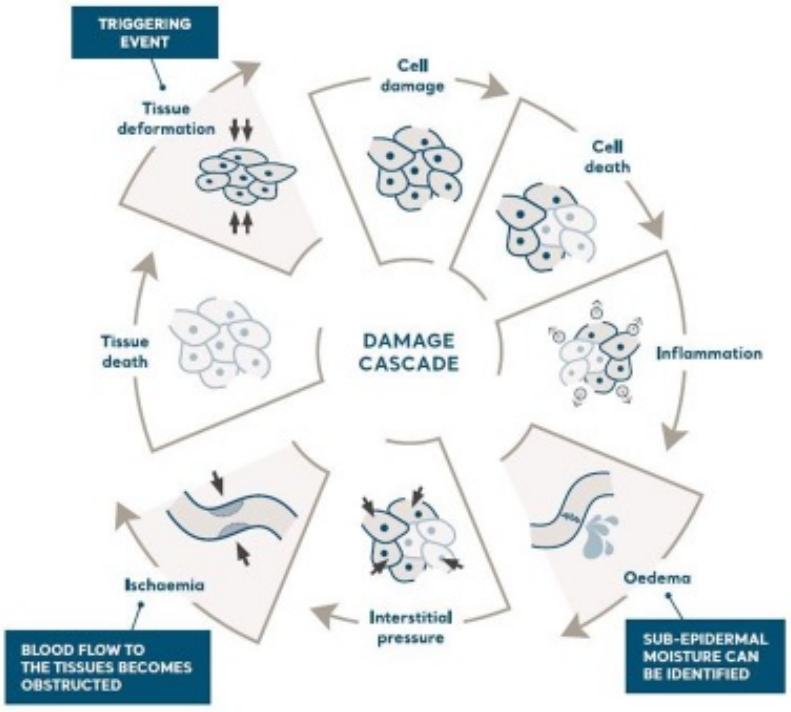
Risk And Skin Assessment

The use of a validated risk assessment tool is recognized as the initial crucial step in prevention.[1] Risk assessment tools are subjective and not anatomy specific, with low sensitivity and specificity (50.6% and 60.1%), depend on independent factors such as age, nutrition, activity, mobility, and skin status[12-14] and are weighted the same, diluting the impact of immobility on pressure injury development.[15] Visual skin assessments offer limited predictive validity[16] and are limited to visible and palpable changes to the skin, and are expertise dependent.[17] Darkly pigmented skin rarely shows a blanching response, and erythema may be hard to detect,[18] potentially contributing to more severe outcomes in these populations.[19] Risk and visual assessments are not intended to assess or identify existing pressure damage[16, 20-22] and risk assessments do not provide information on how patients are responding to adverse events of pressure and shear forces. The visual and physical signs of tissue damage are usually only visible on the skin surface 3-10 days after damage occurs[23] suggesting that skin health can significantly deteriorate before interventions. The current approach of visual skin assessment is a macroscopic observation attempting to identify microscopic changes and identifies existing damage rather than preventing it.[24-26] Relying solely on the current standard of care means that early detection and timely appropriate, anatomy specific interventions are often impossible.

Pressure Injury Damage

Early pressure-induced cell and tissue damage begins at the cellular level (Figure 1).[27] Ischemic damage caused by occlusion of blood vessels can take several hours to develop, however, cell deformation occurs within minutes when tissue is exposed to high pressure strains.[27-30] There may be clinically significant tissue damage before visual or tactile manifestations are observed. The contemporary understanding of the pathophysiology of pressure injuries reveals that tissue inflammation, the first response to damage, causes increased dilation and permeability of surrounding blood vessels.[31] Increased vascular permeability allows fluid to enter the extravascular space causing a build-up of edema or sub-epidermal moisture (SEM) which is invisible to the naked eye.[31] SEM is therefore a biophysical marker, which if raised, enables the detection of pressure injuries before visual manifestation.[23, 26]

Figure 1: Damage Cascade



Cycle of Pressure Injury: adapted from Gefen A, 202038. The SEM Scanner for Early Pressure Ulcer Detection: A 360-degree Review of the Technology. Wounds International. Vol 11, Issue 3: p22-30.

Method

The Provizio™ SEM Scanner (Bruin Biometrics LLC, USA), a CE marked class 11a, FDA approved, non-invasive, handheld skin assessment device, is recognized as an objective method for detection of early invisible tissue damage,[32-35] and was selected based on a review of available technology.[36] (See Figure 2.)

Figure 2: SEM Scanner

Source: Bruin Biometrics LLC

The current clinical practice guidelines recommend the use of SEM as an objective biomarker of risk in adjunct to clinical skin assessment and when assessing individuals with dark pigmented skin[1] given the inherit subjectivity of these methods.

Clinical studies have determined that a SEM Delta (Δ) <0.6 can indicate lower risk for pressure injury while a SEM Delta (Δ) <0.6 is suggestive of increased risk.[32] The device supports identification of specific anatomical areas at increased risk of pressure injury development on average of five days earlier than visual skin assessment.[25,26,32,37,38] By implementing targeted prevention strategies earlier to specific areas of concern, tissue damage identified in the preventable stage may cease progression to tissue death.[24]

The six-week pilot was designed as a quality improvement (QI) process to be used with minimal modifications to existing care pathways and was not required to be subject to institutional review board oversight and ethics committee approvals. Local operational approval was obtained to conduct the pilot on one Medicine unit at a large urban acute facility in Alberta, Canada. The pilot was guided by the *Promoting Action on Research Implementation in Health Services* framework,[39] which proposes that successful implementation is dependent on the interplay of evidence, implementation context and facilitation. Local pressure injury data was collected by the local team using the standardized provincial audit tool. A medical unit with at-risk patients and strong leadership engagement in prevention was chosen for the pilot. The pilot was facilitated by one Clinical Nurse Specialist (CNS) and one Clinical Nurse Educator (CNE) implementation lead. A team comprising six front line nursing champions was identified in collaboration with the CNE and Unit Manager to facilitate implementation.[40] Additional implementation strategies included engaging with participants at multiple levels, fostering local ownership, employing improvement tools to generate practice-based evidence, conducting Plan-Do-Study-Act cycles to develop and refine implementation strategies and support capacity to implement evidence-based intervention.[41]

Six in-person 45-minute training sessions were offered to participants to choose from. Training was supported by industry in collaboration with the CNE and CNS and included a PowerPoint presentation detailing the technology, the standard operating procedure, the significance of SEM Delta (Δ) values and a review of the SSKIN+ bundle. Participants completed one scan on sacrum (Figure 3) and heel locations (Figure 4) of an anatomical model and one supervised return demonstration with a consenting patient. Three scanners and the single patient use sensors were placed in accessible locations on the unit. Pressure injury prevention pamphlets were made available for patients and families in a public area on the unit.

Figure 3: Sacral Scanning Locations

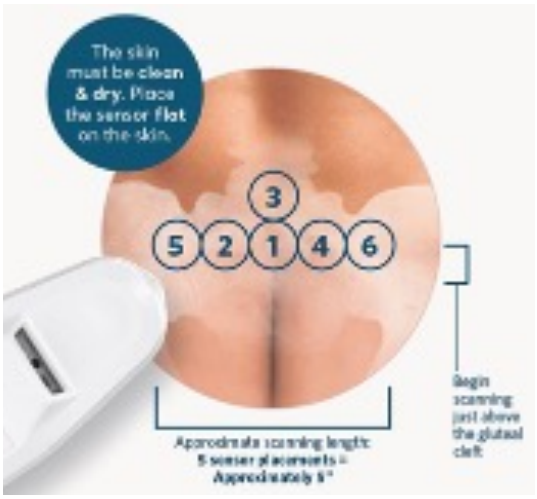


Figure 4: SEM Scanner Applied To Heel

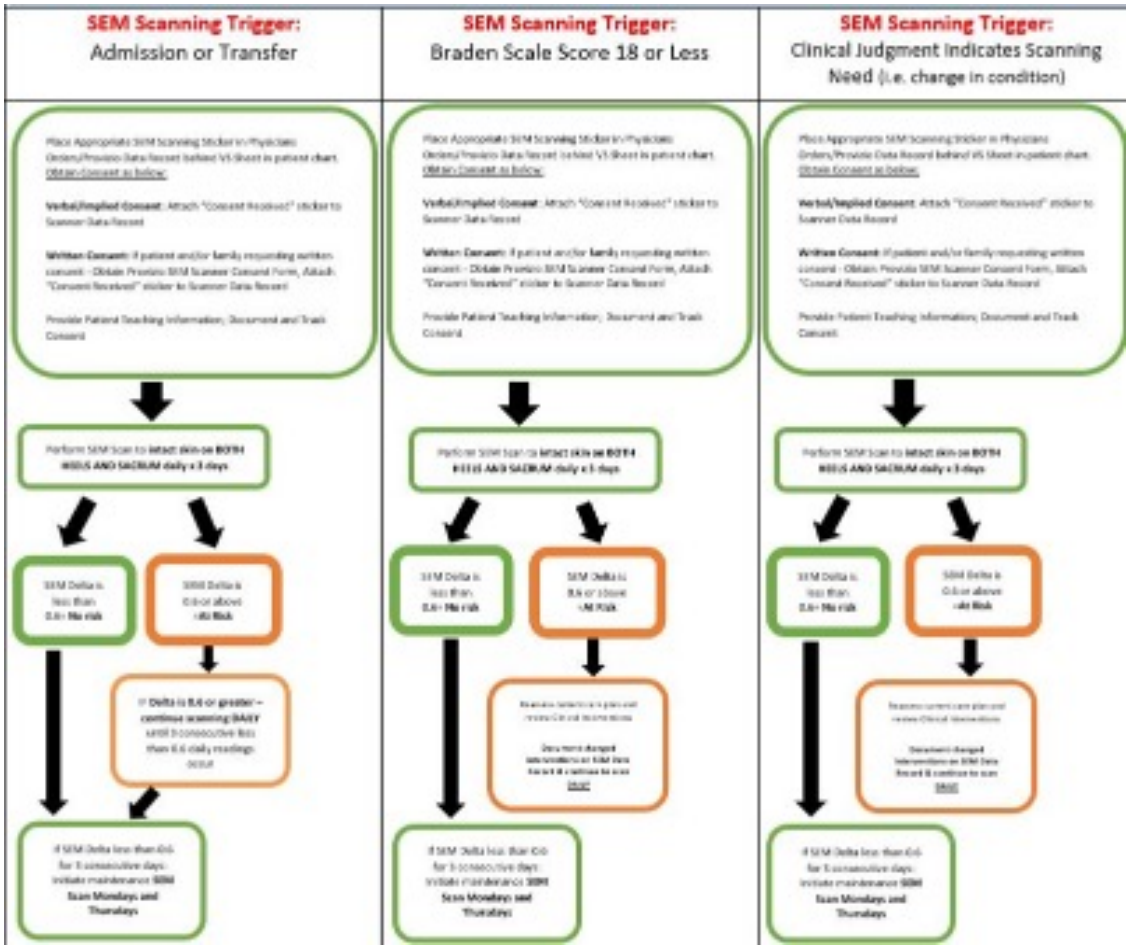
Scans were conducted according to the manufacturer's instructions. A process map (Figure 5) and inclusion criteria (Figure 6) were developed based on review of the literature and in collaboration with the distributor of the device and pilot team. Inclusion criteria included: minimum age 18, Braden Score ≤18, implied consent, scanning locations accessible to scanning and intact skin. Exclusion criteria included Braden score >18, non-intact skin, safety risk to provider for restless or combative patients, patient conditions not appropriate for scanning, sites not accessible to scanning and refusal to participate. Written consent was available if desired from patients or families, otherwise implied consent was obtained.

SEM assessments were performed on the sacum and both heels daily, in the morning during assessments. Standard of care was followed during SEM assessments including risk assessment with the Braden Scale and skin assessment to determine skin changes or redness. Assessments were documented on a data collection form. Scans were completed on included patients daily until three consecutive SEM Delta (Δ) <0.6 were achieved at the sacrum and both heels. Then patients were transitioned to maintenance scanning Mondays and Thursdays. Following assessments, staff determined if the SEM scanner changed their clinical decision-making and documented subsequent interventions.

Figure 6: Inclusion/Exclusion Criteria

INCLUSION CRITERIA	EXCLUSION CRITERIA
• Minimum age 18 • New admission to unit • Braden Scale Total Score 18 or less, or if clinical judgment indicates • Patient, family, or legal representative able to provide verbal implied consent (written optional) • Heels and sacrum accessible to scanning and skin is intact	• Physical act of performing inspections and measurements contraindicated due to patient condition (for example, safety risk or end of life)

Figure 5: Initial Process Map



SEM Delta (Δ) readings were documented on a communication board, and nursing report for facilitated communication. Data was anonymized, scanned, removed from the unit and stored in a locked room. Anonymized data was sent to industry for analysis. During the first four weeks, one ARJO representative was on site for staff support for additional education for staff who did not attend the pre-education. A paper and electronic evaluation form was collected from the team, patients and families to obtain feedback on the experiences with the technology. The Clinical Sustainability Assessment Tool (CSAT)[42] was administered to the implementation team one week after the pilot to obtain feedback.

Results

A total of 78 nursing staff attended the training sessions representing 75% of the unit level nursing program workforce. Two members of the leadership team attended the education; Nursing was the only discipline who attended education sessions, conducted scans and implemented interventions. Allied health teams were provided one education session upon request during week four of implementation but did not participate in the pilot. A total of 97 patients were evaluated over the six-weeks with a total of 2,039 scans completed. Seventy-four per cent of clinical decision-making was changed during assessments (Figure 7 and 8). SEM Delta (Δ) results in the sacral and heel locations trended downwards throughout the pilot (Figure 9). A total of 1,119 total scans had a SEM Delta (Δ) <0.6 indicating raised SEM levels detected, yet 73% of those patients were identified at low risk with the Braden Scale (Scores 15-18).

Figure 7: SEM Delta Results

Anatomical Site	SEM ▲ ≥ 0.6	SEM ▲ ≥ 0.6 (%)	SEM ▲ ≥ 0.6 at anatomical site, with no discolouration (%)	SEM ▲ ≥ 0.6 at anatomical site, identified as 'low risk' via Braden score* (%)	Total scans
Sacrum	437	65.5%	68.6%	73.7%	667
Heels	682	49.7%	78.0%	53.5%	1372
All sites (total)	1119	54.9%	41.0%	73.0%	**2039**

71% (69) total patients with SEM ▲ ≥ 0.6 Identified as 'low risk' via Braden Score, AND had no skin discoloration

*Where risk scores were provided

Figure 8: Clinical Decision-Making

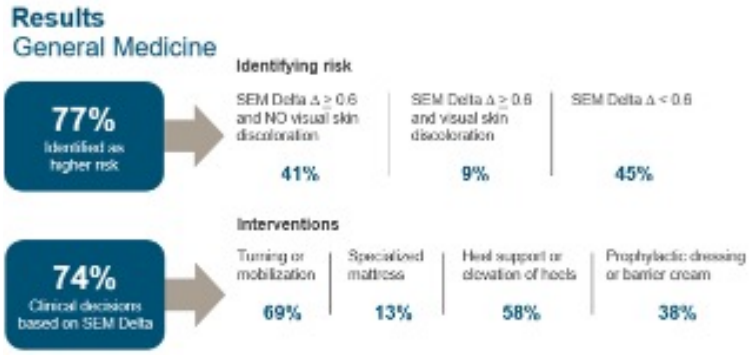
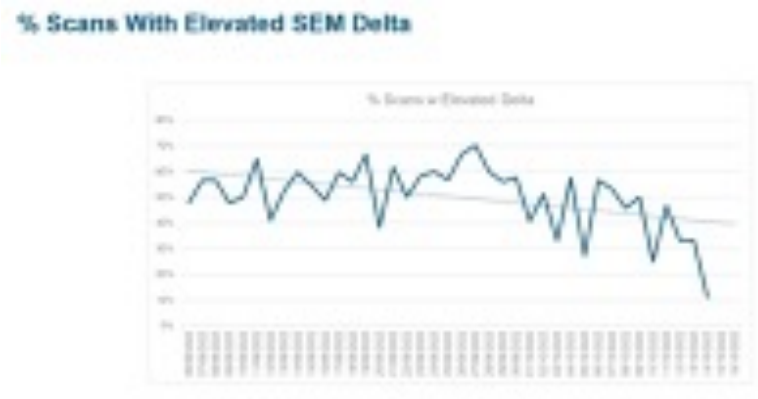


Figure 9: SEM Delta Trending



The baseline facility-acquired pressure injury rate was 9% and after the pilot was 0%: a 100% reduction rate. This was translated in collaboration with the distributor into an annual cost savings of $426,903 for the unit. Cost savings was modeled based on predicted facility acquired rate from historical data from two previous audits, the estimated cost of pressure injuries in Canada,[5] daily scanning and a conservative estimate of 75% reduction of heel and sacrum hospital-acquired pressure injuries from a baseline estimate of 54 HAPI's per year (SEM scanning averages a 90% reduction in acute care,[43] of which would yield a cost savings of $563,099). The estimated cost savings were indicative of material costs.

Upon review of the data from week one-three, the implementation team observed that prophylactic dressings were the first choice for interventions. The implementation team encouraged

basic preventative interventions first, such as increasing turning frequency, repositioning and mobilization prior to application of prophylactic sacral dressings. Some scans were not completed, typically on weekends, and there was a lack of documentation related to skin assessment and skin tone. When there was no documentation on skin assessment, these values were not included in the data analysis. Although the technology appeared to integrate into the current workflow processes, staff suggested that the timing of the scans be changed to reduce workload during day shift. Scan times were changed to one side of the unit scanning patients on day shift and the other side on evening shift during week five. The implementation team recognized self organization[4] by the local team as modifications were recommended by participants and changes were made. Adaptations were made to the process map during week five. The threshold of three consecutive days of normal SEM Delta (Δ) was reduced to two consecutive days to limit sensor consumption and sensor cost within the local pilot budget.

Figure 10: SEM Participant Survey

Provizio SEM Scanner Feedback	Healthcare Providers (Total =20)			Students (Total =8)		
Question	Yes (%)	No (%)	Blank/NA (%)	Yes (%)	No (%)	Blank/NA (%)
In my experience, it was easy to learn to use and operate the device.	100%			100%		
Scanning each patient was quick and I was able to scan each patient easily.	80%	20%		100%		
Assessing patients with a deviation (delta) of 0.6 alerted me to take appropriate clinical action.	100%			100%		
The device adds value and provides additional information to support my decision-making about my patient's pressure injury prevention care.	90%	10%		100%		
The device gave me immediate feedback as to whether the area was improving or not.	90%	10%		100%		
The device provides clinically meaningful data about tissue damage.	85%	15%		100%		
The device can replace risk assessments.	45%	55%		12%	88%	
The pilot increased awareness and engagement of the problems and solutions around pressure injury prevention with Physicians.	80%	15%	5%	100%		
The pilot increased awareness and engagement of the problems and solutions around pressure injury prevention with NPs.	25%		75%	100%		
The pilot increased awareness and engagement of the problems and solutions around pressure injury prevention with Allied Health teams.	90%	10%		100%		
Would you adopt the device into your clinical practice?	85%	15%		100%		
Do you believe the pilot was successful?	80%	20%		88%	12%	
Do you believe the pilot was worth the implementation effort on your part?	85%	15%		75%	12%	12%

The scanning trigger of a Braden Score of 18 or less was amended to <18. A queue for referral to the allied health team was added for independent patients with a SEM Delta (Δ) <0.6 on admission. This change should also have included patients with mobility issues and is recommended for future process maps.

Twenty evaluations were completed by participants, eight by students (Figure 10) and one by a patient (Figure 11) with positive results indicating acceptability of technology. The CSAT identified organizational readiness as a domain with the largest variability, highlighting opportunities to support future implementation including establishing systems to support various practice needs, ensuring that the practice is feasible and has sufficient resources to achieve goals, adequate staffing to achieve goals and integration into operations. This feedback supported a greater practical and scientific understanding of critical contextual factors that support clinical practices over time.

Adverse Events

No adverse or serious adverse events were reported during the pilot relating to the use of the Provizio™ SEM Scanner. Two patients developed pressure injuries during the pilot, but these were determined to be unavoidable through non-adherence to interventions due to complexity of the individual patients.

Discussion

The introduction of SEM scanning illuminated

Figure 11: SEM Patient Survey

Provizio SEM Scanner Feedback	Patients (Total = 1)	
Question	**Yes (%)**	**No (%)**
I know more about what pressure injuries are and how they can happen.	100%	
I know more about the factors that increase my risk of developing a pressure injury.	100%	
I know more about strategies to help me prevent a pressure injury from developing.	100%	
I have learned about the Provizio™ SEM Scanner technology and how that can help prevent pressure injuries.	100%	
After learning about the Provizio™ SEM Scanner technology I am confident that my care team can help prevent pressure injuries from developing while I am in care.	100%	
I know that I or my family or caregivers can actively participate in pressure injury care planning if able to keep my skin safe.	100%	
I know who to communicate with on my care team if I have concerns or questions about pressure injury prevention.	100%	

educational opportunities to strengthen documentation and critical thinking surrounding the SSKIN+ bundle application, and the importance of multidisciplinary engagement and management of front-line resources. Risk and skin assessments, including skin tone variance, were not consistently documented. The Provizio™ SEM scanner can upload data results into the Electronic Medical Record system, mitigating challenges with consistent documentation. Support surface selection was based on a list of current available support surfaces prompting the need for an up-to-date algorithm to support decision-making. Turning and repositioning was identified as an intervention, however on the ground support identified opportunities for additional education related to turning frequencies and side-lying positioning, which is significant for appropriate offloading of pressure. Incontinence associated dermatitis (IAD) on two occasions observed by the project lead were not diagnosed. IAD is frequently misdiagnosed as a stage one or two pressure injury[45] as visual skin assessments are unreliable.[16]

Prior to the pilot, the current standard of care of risk assessments and skin assessments led to inconsistencies in SSKIN+ bundle utilization. This was apparent with the introduction of the SEM assessment as well; however, clinical participants increased their clinical decision-making by 74% after scanning with the addition of objective SEM Delta (Δ) assessments. Participants developed care plans using the SSKIN+ bundle and reliable objective SEM assessments and were able to focus their time and resources amongst the patient groups with elevated SEM Delta (Δ) scores. There were challenges with participants reviewing previous SEM Delta (Δ) scores and SSKIN+ interventions to either increase or decrease the interventions. The implementation team communicated this gap to participants during week four and reinforced the SSKIN+ bundle to the participants by providing a new reference tool to stratify the interventions on a continuum of low, moderate and high risk to aid in decision-making.

This change shifted participants from choosing sacral prophylactic dressings as a first line of intervention to considering other options, such as mobilization or turning and repositioning. Health-care provider compliance rates to prevention strategies and guidelines in acute care vary, suggesting that there is opportunity to improve the implementation of basic strategies including repositioning, heel elevation, nutrition support, and moisture management.[46] Future education for subsequent implementation should include documentation, reinforcement of landmarking, scanning technique, SSKIN+ bundle implementation, evaluation of care planning and a review of maintenance case studies to support evaluation of interventions.

There was limited discussion of abnormal SEM assessments at rapid round discussions, which was an opportunity for improvement. An interprofessional approach is required to mitigate risk factors such as mobility, nutrition and moisture management as part of a comprehensive pressure injury prevention care plan.[47] Health-care leaders must consider the importance of interprofessional collaboration and role clarity to ensure patients are receiving the necessary care from the care team. Developing team skills and interprofessional relationships can positively impact pressure injury prevention.[47] The implementation team observed that participants and student discussion of SEM Delta (Δ) results with patients and families raised awareness of pressure injuries and the technology for early detection.

The pilot started with two hundred sensors that needed to be reordered weekly, which was a stressor for the implementation lead to coordinate. The team did not project sensor consumption, therefore weekly incremental sensor costs were a concern for the operational leadership team, prompting discussions related to reducing sensor consumption prompting better adaptation into staff workflow, and enhanced interventions including consultations to allied health. Full implementation could alleviate challenges with re-ordering sensors, as the unit could see increased financial and quality of care benefit through the reduction of facility-acquired pressure injuries. Imbedding innovation requires people to work together to solve problems using give-and-take and this was achieved through open dialogue, strong leadership and openness to change.[44] The implementation team harnessed feedback productively and viewed differing perspectives as the raw ingredients for multifaceted solutions.[44]

Additional opportunities identified through team communication and voluntary written evaluations included needing more time dedicated to addressing pressure injury risk factors through implementation of strategies with a team approach, workload challenges limiting ability to attend to prevention due to competing priorities and confidence in technology. The pilot took place September 2022 when the team was experiencing post-pandemic fatigue, which may have translated into a task-focused approach to care. Staff were positive during the pilot as the technology was, "motivational, helped us to make a difference and took our mind off the pandemic." Third year nursing students were eager to learn about the technology and brought positive energy while integrating SEM into their practice.

There is a constant and large drive to implement changes without a thorough assessment of the environmental and establishment organizational readiness,[48] a critical step in the implementation process.[49] Organizational readiness refers to the extent to which organizational members are psychologically and behaviourally prepared to implement organizational change including internal support and resources to effectively manage the practice change.[50] Leadership, facilitation, organizational and staff commitment, evaluation and feedback and resources dedicated to the pilot were significant contextual factors identified as important facilitators. Staff recognized the impact on decision-making through measuring SEM and interpreting and implementing the SSKIN+ bundle to support resource stewardship while improving quality care.

Limitations

Innovation may be hindered by tensions in the innovation process inherent to health care, such

as risk aversion, lack of agility and nimbleness, along with challenges with testing innovations.[51] Within the current pilot, our implementation and leadership teams took this opportunity head-on to test out innovation to improve pressure injury prevention and are exploring the multi-factorial resources for future implementation. Documentation of risk and skin assessments and communications related to the transitions to maintenance scanning were inconsistent limiting analysis. The implementation of the SSKIN+ bundle was limited to the nursing discipline.

Conclusion

Current literature suggests the use of SEM to objectively assess the skin and underlying tissues for early pressure damage.[1, 24] The results demonstrated that targeting elevated SEM Delta (Δ) with early and anatomy-specific, evidence informed prevention strategies, reduce SEM Delta (Δ) and could eliminate preventable facility-acquired pressure injuries resulting in improved patient outcomes and higher quality care. The seamless inclusion of an objective assessment into the current standard of care, along with adaptations, were successfully implemented. An understanding of contextual factors is necessary for supporting the translation of evidence into practice. Future work will focus on sharing results with teams and consideration of future adoption of SEM technology.

Acknowledgements

The authors would like to thank leadership and front-line teams at the Misericordia Hospital Medicine program, Professional Practice and Clinical Learning leadership, McEwan University third year nursing students, ARJO and Jacqueline Frost.

Marlene Varga (She/Her) MSc BScN, Pressure Injury Prevention Lead,
Covenant Health, AB.
Misha Jadoo (She/Her) BScN RN, National Wound Care Specialist ARJO.
Sebastien Normandin, BHK ARJO.
Jacqueline Brayshaw BN RN, Covenant Health, AB.

References

1. European Pressure Ulcer Advisory Panel, National Pressure Injury Advisory Panel and Pan Pacific Pressure Injury Alliance. Prevention and Treatment of pressure ulcers/injuries. Clinical Practice Guideline. The International Guideline. Emily Haesler (Ed). EPUAP/NPIAP/PPPIA: 2019.
2. Anrys C, Van Tiggelen H, Verhaeghe S, Van Hecke A, Beeckman D. Independent risk factors for pressure ulcer development in a high-risk nursing home population receiving evidence-based pressure ulcer prevention: Results from a study in 26 nursing homes in Belgium. Int Wound J. 2019 Apr;16(2):325-333.
3. Moore Z, Cowman S, Conroy RM. A randomised controlled clinical trial of repositioning, using the 30° tilt, for the prevention of pressure ulcers. J Clin Nurs. 2011 Sep;20(17-18):2633-44.
4. Woodbury MG, Houghton PE. Prevalence of pressure ulcers in Canadian healthcare settings. Ostomy Wound Manage. 2004 Oct;50(10):22-4, 26, 28, 30, 32, 34, 36-8.
5. Chan B, Ieraci L, Mitsakakis N, Pham B, Krahn M. Net costs of hospital-acquired and pre-admission PUs among older people hospitalised in Ontario. J Wound Care. 2013 Jul;22(7):341-2, 344-6.
6. Demarré L, Van Lancker A, Van Hecke A, Verhaeghe S, Grypdonck M, Lemey J, et al. The cost of prevention and treatment of pressure ulcers: A systematic review. Int J Nurs Stud. 2015 Nov;52(11):1754-74.
7. Padula WV, Pronovost PJ, Makic MBF, Wald HL, Moran D, Mishra MK, et al. Value of hospital resources for effective pressure injury prevention: a cost-effectiveness analysis. BMJ Qual Saf. 2019 Feb;28(2):132-141.
8. Chapman S. Preventing and treating pressure ulcers: evidence review. Br J Community Nurs. 2017 Mar;22 Suppl 3(Sup3):S37-S40.
9. Varga MA, Holloway SL. The lived experience of the wound care nurse in caring for patients with pressure ulcers. Int Wound J. 2016 Apr;13(2):243-51.
10. Pittman J, Beeson T, Terry C, Dillon J, Hampton C, Kerley D, et al. Unavoidable pressure ulcers: Development and testing of the Indiana university health pressure ulcer prevention inventory. J Wound Ostomy Continence Nurs. 2016 Jan 1;43(1):32-8.
11. Black JM, Edsberg LE, Baharestani MM, Langemo D, Goldberg M, McNichol L, et al. Pressure ulcers: avoidable or unavoidable? Results of the National Pressure Ulcer Advisory Panel Consensus Conference. Ostomy Wound Manage. 2011 Feb;57(2):24-37.
12. Waterlow J. From costly treatment to cost-effective prevention: using Waterlow. Br J Community Nurs. 2005 Sep;10(9):S25-6, S28, S30.
13. Bergstrom N, Braden BJ, Laguzza A, Holman V. The Braden Scale for predicting pressure sore risk. Nurs Res. 1987 Jul-Aug;36(4):205-10.
14. Qaseem A, Mir TP, Starkey M, Denberg TD; Clinical Guidelines Committee of the American College of Physicians. Risk assessment and prevention of pressure ulcers: a clinical practice guideline from the American College of Physicians. Ann Intern Med. 2015 Mar 3;162(5):359-69.
15. Byrne S, Patton D, Avsar P, Strapp H, Budri A, O'Connor T,

et al. Sub epidermal moisture measurement and targeted SSKIN bundle interventions, a winning combination for the treatment of early pressure ulcer development. Int Wound J. 2023 Aug;20(6):1987-1999.
16. Moore ZE, Patton D. Risk assessment tools for the prevention of pressure ulcers. Cochrane Database Syst Rev. 2019 Jan 31;1(1):CD006471.
17. Bryant RA, Moore ZE, Iyer V. Clinical profile of the SEM Scanner - Modernizing pressure injury care pathways using Sub-Epidermal Moisture (SEM) scanning. Expert Rev Med Devices. 2021 Sep;18(9):833-847.
18. Grimes PE. Management of hyperpigmentation in darker racial ethnic groups. Semin Cutan Med Surg. 2009 Jun;28(2):77-85.
19. Gunowa NO. Skin tone bias and wound care: highlighting the current evidence and addressing the gaps in knowledge of dark skin tones. Wounds UK. 2022 Jan 1;18(1).
20. Pieper B, Mott M. Nurses' knowledge of pressure ulcer prevention, staging, and description. Adv Wound Care. 1995 May-Jun;8(3):34, 38, 40 passim.
21. Pancorbo-Hidalgo PL, Garcia-Fernandez FP, Lopez-Medina IM, Alvarez-Nieto C. Risk assessment scales for pressure ulcer prevention: a systematic review. J Adv Nurs. 2006 Apr;54(1):94-110.
22. Hiser B, Rochette J, Philbin S, Lowerhouse N, Terburgh C, Pietsch C. Implementing a pressure ulcer prevention program and enhancing the role of the CWOCN: impact on outcomes. Ostomy Wound Manage. 2006 Feb;52(2):48-59.
23. Moore Z, Patton D, Rhodes SL, O'Connor T. Subepidermal moisture (SEM) and bioimpedance: a literature review of a novel method for early detection of pressure-induced tissue damage (pressure ulcers). Int Wound J. 2017 Apr;14(2):331-337.
24. Budri AMV, Moore Z, Patton D, O'Connor T, Nugent L, Avsar P. Sub-epidermal moisture measurement: an evidence-based approach to the assessment for early evidence of pressure ulcer presence. Int Wound J. 2020 Dec;17(6):1615-1623.
25. O'Brien G, Moore Z, Patton D, O'Connor T. The relationship between nurses assessment of early pressure ulcer damage and sub epidermal moisture measurement: a prospective explorative study. J Tissue Viability. 2018 Nov;27(4):232-237.
26. Okonkwo H, Bryant R, Milne J, Molyneaux D, Sanders J, Cunningham G, et al. A blinded clinical study using a subepidermal moisture biocapacitance measurement device for early detection of pressure injuries. Wound Repair Regen. 2020 May;28(3):364-374.
27. Oomens CW, Bader DL, Loerakker S, Baaijens F. Pressure induced deep tissue injury explained. Ann Biomed Eng. 2015 Feb;43(2):297-305.
28. Gawlitta D, Li W, Oomens CW, Baaijens FP, Bader DL, Bouten CV. The relative contributions of compression and hypoxia to development of muscle tissue damage: an in vitro study. Ann Biomed Eng. 2007 Feb;35(2):273-84.
29. Fletcher J, Barrett S. Improving holistic assessment of chronic wounds: how to meet patient expectation using the new Best Practice Statement. Wounds UK. 2018 Nov 1;14(5).
30. Gefen A. The future of pressure ulcer prevention is here: detecting and targeting inflammation early. EWMA J. 2018 Oct 1;19(2):7-13.
31. Gefen A, Alves P, Ciprandi G, Coyer F, Milne CT, Ousey K, et al. Device-related pressure ulcers: SECURE prevention. J Wound Care. 2020 Feb 1;29(Sup2a):S1-S52.
32. Gershon S, Okonkwo H. Evaluating the sensitivity, specificity and clinical utility of algorithms of spatial variation in sub-epidermal moisture (SEM) for the diagnosis of deep and early-stage pressure-induced tissue damage. J Wound Care. 2021 Jan 2;30(1):41-53.
33. Harrow JJ, Mayrovitz HN. Subepidermal moisture surrounding pressure ulcers in persons with a spinal cord injury: a pilot study. J Spinal Cord Med. 2014 Nov;37(6):719-28.
34. Clendenin M, Jaradeh K, Shamirian A, Rhodes SL. Inter-operator and inter-device agreement and reliability of the SEM Scanner. J Tissue Viability. 2015 Feb;24(1):17-23.
35. Oliveira AL, Moore Z, O Connor T, Patton D. Accuracy of ultrasound, thermography and subepidermal moisture in predicting pressure ulcers: a systematic review. J Wound Care. 2017 May 2;26(5):199-215.
36. Scafide KN, Narayan MC, Arundel L. Bedside technologies to enhance the early detection of pressure injuries: a systematic review. J Wound Ostomy Continence Nurs. 2020 Mar/Apr;47(2):128-136.
37. Bates-Jensen BM, McCreath HE, Patlan A. Subepidermal moisture detection of pressure induced tissue damage on the trunk: the pressure ulcer detection study outcomes. Wound Repair Regen. 2017 May;25(3):502-511.
38. Kim CG, Park S, Ko JW, Jo S. The relationship of subepidermal moisture and early stage pressure injury by visual skin assessment. J Tissue Viability. 2018 Aug;27(3):130-134.
39. Kitson A, Harvey G, McCormack B. Enabling the implementation of evidence based practice: a conceptual framework. Qual Health Care. 1998 Sep;7(3):149-58.
40. Rogers E. Diffusion of innovations. 5th ed. New York: Free Press; 2003.
41. Leeman J, Rohweder C, Lee M, Brenner A, Dwyer A, Ko LK, et al. Aligning implementation science with improvement practice: a call to action. Implement Sci Commun. 2021 Sep 8;2(1):99.
42. Malone S, Prewitt K, Hackett R, Lin JC, McKay V, Walsh-Bailey C, Luke DA. The Clinical Sustainability Assessment Tool: measuring organizational capacity to promote sustainability in healthcare. Implement Sci Commun. 2021 Jul 17;2(1):77.
43. Burns M (2020). Real World Evidence Accepted and presented at EWMA Conference.
44. Lanham HJ, Leykum LK, Taylor BS, McCannon CJ, Lindberg C, Lester RT. How complexity science can inform scale-up and spread in health care: understanding the role of self-organization in variation across local contexts. Soc Sci Med. 2013 Sep;93:194-202.
45. Voegeli D. Incontinence-associated dermatitis: new insights into an old problem. Br J Nurs. 2016 Mar 10-23;25(5):256, 258, 260-2.

46. Edsberg LE, Cox J, Koloms K, VanGilder-Freese CA. Implementation of pressure injury prevention strategies in acute care: results from the 2018-2019 International Pressure Injury Prevalence Survey. J Wound Ostomy Continence Nurs. 2022 May-Jun 01;49(3):211-219
47. Heerschap C, Woo KY. Formal caregiver experiences of caring for individuals at risk for or with a pressure injury: a metasynthesis. Adv Skin Wound Care. 2022 Dec 1;35(12):680-7.
48. McMillan K. A critical organizational analysis of frontline nurses' experience of rapid and continuous change in an acute health care organization [PhD thesis]. Ottawa: University of Ottawa; 2018.
49. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: systematic review and recommendations. Milbank Q. 2004;82(4):581-629.
50. Weiner BJ, Amick H, Lee SY. Conceptualization and measurement of organizational readiness for change: a review of the literature in health services research and other fields. Med Care Res Rev. 2008 Aug;65(4):379-436.
51. Haring M, Freigang F, Amelung V, Gersch M. What can healthcare systems learn from looking at tensions in innovation processes? A systematic literature review. BMC Health Serv Res. 2022 Oct 28;22(1):1299.