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ORIGINAL RESEARCH

Implementation of Pressure Injury Prevention Best Practices Across 6 Canadian Rehabilitation Sites: Results From the Spinal Cord Injury Knowledge Mobilization Network

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Abstract

Objective: To use the theoretical frameworks of implementation science to implement pressure injury (PI) prevention best practices in spinal cord injury (SCI) rehabilitation.

Design: Quality improvement.

Setting: Six Canadian SCI rehabilitation centers.

Participants: Inpatients (N=2371) admitted from 2011 to 2015.

Interventions: The SCI Knowledge Mobilization Network (SCI KMN) selected and implemented 2 PI prevention best practices at 6 Canadian SCI rehabilitation centers: (1) completing a comprehensive PI risk assessment comprised of a structured risk assessment instrument followed by an individualized, interprofessional risk factor determination and prevention plan; and (2) providing structured and individualized PI prevention patient education. Active Implementation Frameworks provided a systematic approach to best practice implementation.

Main Outcome Measures: Implementation indicators (completion rates) and patient outcomes (PI incidence, patient education survey).

Results: After implementation, risk assessment completion rates improved from 46% to 94% ($P<.05$). Between initial (2012-2013) and full (2014-2015) implementation stages, completion rates improved for both interprofessional risk factor determination (67% to 96%) and prevention plans (67% to 94%). Documentation of patient education also increased to 86% (vs. 71% preimplementation). At rehabilitation admission 22% of patients had PIs, with 14% of individuals developing new PIs during rehabilitation. The overall PI prevalence was 30%. Considering only PIs of stage 2 or greater, prevalence was 21% and incidence 7%. There were no statistically significant differences in PI incidence between pre- and postimplementation. Patient education surveys indicated that PI education improved patients' knowledge of prevention strategies.

Conclusions: Active Implementation Frameworks supported successful implementation of PI prevention best practices across the 6 participating SCI KMN sites. Achieving a reduction in PI incidence will require additional measures, and there is an ongoing need to strengthen the evidence base underpinning PI prevention guidelines.

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Despite substantial investments in clinical research and best practice guideline development, translating evidence into clinical practice remains a significant challenge.[1] The incorporation of existing evidence into routine clinical practice is poor[2] and the pace slow.[3,4] Prior studies in the context of spinal cord injury (SCI) rehabilitation underscore that simply publishing evidence or practice guidelines does little to affect practice.[5-7] Instead, targeted implementation efforts are required to encourage uptake, and even then, results are mixed.[5,6,8-11] The emerging field of implementation science provides structured frameworks to support successful implementation of evidence-based practices and increase the likelihood of sustained practice change.[12-15] Implementation science is "the scientific study of methods to promote the systematic uptake of research findings and other evidence-based practices into routine practice, and, hence, to improve the quality and effectiveness of health services."[16(p.3)]

The SCI Knowledge Mobilization Network (SCI KMN) is a community of practice currently comprising 7 rehabilitation centers across Canada. Since its inception in 2011, the primary focus of the SCI KMN has been to enhance the translation and incorporation of clinical best practices into routine SCI rehabilitation by building capacity and expertise in sustainable implementation. The SCI KMN used the Active Implementation Frameworks of the National Implementation Research Network (NIRN) (University of North Carolina at Chapel Hill)[17-20] and was supported by NIRN-affiliated consultants. By working collaboratively to translate and embed mutually prioritized best practices into clinical settings, participating sites in the SCI KMN aim to standardize and improve care for persons undergoing SCI rehabilitation across Canada.

The initial area of focus was pressure injury (PI) prevention, which was an identified priority of the funders. PIs are common and costly complications after SCI, which adversely affect quality of life,[21-23] cost of care,[24-27] and contribute to increased mortality.[28,29] In 2007, Medicare (the United States) estimated that each stage 3 or 4 PI added $43,180 to a hospital stay.[30] In 2011, the U.S. Agency for Healthcare Research and Quality reported the annual cost for PIs as $9.1-$11.6 billion.[31] In the United Kingdom, PIs accounted for approximately 4% of national health spending in 2000 (£1.4-£2.1 billion annually).[24] In Australia, PI treatment accounted for approximately 1.9% of all public hospital funding for a total of $983 million (Australian dollars) per year during 2012-2013.[32] Compared to PI treatment, PI prevention is thought to be more cost-effective with estimated expenditures less than a tenth of that of caring for an individual with PI.[28]

Despite the importance of PI prevention after SCI, studies indicate that in many circumstances clinical practice fails to align with the available evidence or guidelines.[8,33,34] Barriers limiting the translation of evidence into routine practice include inconsistency in practice across clinicians,[8,33,34] clinician resistance to change and the accompanying receptivity to learning new skills,[8] time required to learn and implement new skills,[8] and limited organizational support.[8,34] Below we describe the experience of the SCI KMN and associated outcomes related to the systematic implementation[17-19] of 2 PI prevention best practices identified from clinical practice guidelines.[35-37] Implementation was based on theoretical frameworks from the academic discipline of implementation science. Primary outcomes were indicators which reflected the successful implementation of selected practices (eg, practice completion rates), whereas secondary outcomes addressed patient outcomes (eg, PI incidence).

List of abbreviations:

FMC	**Foothills Medical Centre**
GRH	**Glenrose Rehabilitation Hospital**
IRDLM	**Institut de Réadaptation Gingras-Lindsay-de-Montréal**
IRDPQ	**Institut de Réadaptation en Déficience de Physique de Québec**
IRGLM	**Institut de Réadaptation Gingras-Lindsay-de-Montréal**
NIRN	**National Implementation Research Network**
PI	**pressure injury**
PI-SJHC	**Parkwood Institute—St. Joseph's Health Centre**
SCI	**spinal cord injury**
SCI KMN	**Spinal Cord Injury Knowledge Mobilization Network**
SCIPUS	**Spinal Cord Injury Pressure Ulcer Scale**
TRI-UHN	**Toronto Rehabilitation Institute—University Health Network**

Methods

The 6 participating SCI KMN sites were Glenrose Rehabilitation Hospital (GRH, Edmonton, Alberta), Foothills Medical Centre (FMC, Calgary, Alberta), Parkwood Institute - St. Joseph's Health Care (PI-SJHC, London, Ontario), Toronto Rehabilitation Institute – University Health Network (TRI-UHN, Toronto, Ontario), Centre Intégré Universitaire de Santé et de Services Sociaux du Centre-Sud-de- l'île-de-Montréal—Institut de Réadaptation Gingras-Lindsay-de-Montréal (IRGLM, Montréal, Québec), and Centre Intégré Universitaire de Santé et de Services Sociaux de la Capitale-Nationale—Institut de Réadaptation en Déficience Physique de Québec (IRDPQ, Québec City, Québec). A seventh site, Stan Cassidy Centre for Rehabilitation in Fredericton, New Brunswick, joined the SCI KMN after PI best practice implementation. All sites are specialized rehabilitation centers with beds dedicated to patients with traumatic and nontraumatic SCI. Characteristics of the rehabilitation centers and baseline PI practices have been summarized elsewhere.[38]

Implementation methods

After the identification and selection of specific practices for implementation (described below), the SCI KMN enlisted the expertise of NIRN consultants who provided training and mentorship to each site in the application of Active Implementation Frameworks.[12,17-19] The use of the Active Implementation Frameworks within the context of the SCI KMN has been previously described[18] and briefly consisted of the following:

(1) *Site implementation team:* Each participating site established a team led by a knowledge mobilization specialist and site lead(s), which was accountable for implementing and sustaining new practices. The knowledge mobilization specialist was a dedicated role supported by the funders to coordinate implementation activities and provide logistical support and leadership. Training and support in content expertise (implementation science) was provided by NIRN. Teams varied in size and composition between sites (4-10 members), depending on local needs and staff availability, and could include clinical staff, hospital leadership, and individuals with

SCI. The site implementation team ensured that implemented processes were relevant within the local context, using a practice profiling tool.[12]

(2) *Implementation drivers:* Implementation drivers (eg, staff competency, leadership, organizational) are facilitators required for successful implementation.[19] The state of key implementation drivers was assessed at each site using a structured drivers analysis at multiple time points. After gaps were identified, site-specific action plans were created to address deficiencies and support clinicians through the required practice change.
(3) *Stages of implementation:* Stages of implementation include exploration (determining what to implement), installation (how to implement), initial implementation (trialing and adapting the practice), and full implementation (sustaining practice).[39] The stages of implementation within the SCI KMN have been previously described.[18]
(4) *Improvement cycles:* Data-driven improvement cycles were conducted throughout implementation stages.[12] Processes were refined through auditing of implementation results and providing feedback to staff members.

Practice selection and operationalization

During exploration, 48 candidate best practices for implementation were identified using 3 existing PI practice guidelines.[35-37] A modified Delphi process[18] was then employed to build consensus and select specific best practices for implementation. The Delphi process included clinician, administration, research, consumer and funder perspectives. The following practices were selected based on evidence, importance, need, feasibility, sustainability, and scalability:

(1) Completion of a comprehensive PI risk assessment and prevention plan comprising the following:
  a. Structured risk assessment instrument
  b. Interprofessional risk factor determination and prevention plan
(2) Provision of PI prevention education to patients, incorporating the following elements:
  a. Structured group educational sessions
  b. Educational materials (handouts, online resources)
  c. Unstructured, individualized education (one-on-one, bedside)

In the installation stage, best practices were translated into concrete activities that met the needs of each respective site. To accomplish this, a Central Operationalization Team, comprising SCI KMN leadership and knowledge mobilization specialists from each site, was formed. The team broke down selected practices into actionable items with the goal of achieving a base level of standardization, while allowing some site-specific variation in the approach to implementation. The latter was an acknowledgement of site-specific differences in the environment, preimplementation practices, and barriers to implementation, which necessitated site-specific action plans as described above. In other words, although there was agreement regarding *what* to implement, some flexibility was allowed regarding *how* to implement.

Sites were given the option of implementing 1 of 2 PI risk assessment scales previously recommended for use with SCI.[36] Three sites with mixed neurorehabilitation units (table 1) selected the Braden,[40] a general risk assessment scale already in use at their sites. The other 3 sites with dedicated SCI beds implemented the SCI Pressure Ulcer Scale (SCIPUS),[41] a risk assessment scale specific to SCI. Formatting and operational definitions of the SCIPUS were agreed on by the 3 sites to ensure consistency.[19] Target completion time for the Braden was within 24 hours of admission, whereas the SCIPUS was to be completed within 72 hours of admission due to the requirement for laboratory test results (serum albumin, glucose, hematocrit).

Site-specific forms, highlighting PI risk factors and consolidating actionable prevention strategies, were created to facilitate completion of the interprofessional prevention plan by increasing ease and efficiency for clinicians. The process for completion of the prevention plan needed to meet the following criteria: (1) completion within 10 days of admission for high-risk individuals (Braden score <13 or SCIPUS score ≥ 6); (2) inclusion of physical environment, demographic, physical, medical, and psychosocial PI risk factors; (3) identification of possible prevention strategies; and (4) completion by at least 4 members of relevant professions (eg, doctors, nurses, physical therapists, occupational therapists, dietitians/nutritionists, social workers, psychologists). Prevention plan forms were refined through improvement cycles in the initial implementation stage. Final site-specific forms are provided in supplemental appendix S1 (available online only at http://www.archives-pmr.org/). Prevention plan completion was supported by training, coaching, mentorship, and feedback provided to members of the interprofessional teams.

The second implemented practice was the provision of education addressing PI prevention to patients (and family members) through group classes, educational materials, and unstructured one-on-one education. Components of education included skin health, skin inspections, PI risk factors, and prevention strategies. Education needed to incorporate adult learning principles and ensure materials were written at a sixth-grade reading level. Education satisfaction rates were evaluated using a customized 4-question survey, completed within 2 weeks of discharge.

Data collection and analysis

PI implementation activities were reviewed by site research ethics boards. At 3 sites (TRI-UHN, IRGLM, IRDPQ) implementation actives were deemed quality improvement and granted exemption status. At the remaining sites (GRH, FMC, PI-SJHC) approval was granted by their institutional research ethics boards.

Data were abstracted from the charts of 341 patients preimplementation (discharge dates 2011-early 2012) and 2030 patients postimplementation (discharge dates 2012-2015; TRI-UHN 2012-2014), and entered into a secure online, centralized data collection platform. Implementation was initiated at slightly different time points for each site (2012-2013). To evaluate changes over time, postimplementation data from initial implementation (2012-2013) was compared to data after full implementation (2014-2015).

Completion rates were retrospectively determined for the risk assessment instruments and interprofessional prevention plan. For the purpose of data collection, the interprofessional risk factor determination and prevention plan form was considered complete if 4 or 5 (depending on site) different professions completed it within 10 days of admission. The plan was considered partial if it was completed by at least 1 profession and late if it was completed after 10 days postadmission. Data regarding the delivery of patient education was retrospectively collected from a variety of sources including medical charts, attendance logs from

Table 1 Demographics for each site and entire cohort

	FMC	GRH	IRDPQ	IRGLM	TRI-UHN	PI-SJHC	Overall	n
Men, %	73	73	72	71	66	66	69	2371
Traumatic SCI, %	55	N/A	N/A	60	36	33	45	1855
Paraplegia, %	53	N/A	N/A	51	56	56	54	1723
Complete injury, %	28	N/A	N/A	21	13	13	17	1693
Preimplementation (n)	50	52	50	70	69	50	341	341
Postimplementation (n)	165	188	211	467	741	258	2030	2030
Unit type	Mixed	Mixed	Mixed	SCI	SCI	SCI	.	2371
Number of SCI beds	15	15	26	25	60	15	156	.
Age (y)	48.6 (18)	51.4 (18.8)	53.8 (18.9)	51.8 (18.3)	53.9 (18.3)	57.3 (16.8)	53.1 (18.3)	2371
Braden score	15.9 (2.6)	16.3 (2.6)	16.7 (3.1)	17.7 (2.8)*	17.7 (2.9)*	16.7 (4)*	16.5 (2.9)	794
SCIPUS score	N/A	N/A	N/A	9.3 (2.7)	8.3 (2.6)	8.9 (2.7)	8.7 (2.7)	1359
Length of stay (d)	75 (51)	63 (35)	77 (55)	64 (39)	64 (39)	52 (35)	65 (42)	1854

NOTE. Information on injury characteristics was not available for 2 sites (GRH, IRDPQ). Unit type indicates whether SCI patients were treated in a dedicated SCI rehabilitation unit or in a mixed neurorehabilitation unit. SDs are in parentheses. The final column indicates the total number (n) of patients with demographic information available for each row of data.

* Collected preimplementation only.

class sessions, and self-report from a discharge survey (postimplementation only). Data for PI prevalence, incidence, location, and stage (National Pressure Ulcer Advisory Panel guidelines) were retrospectively abstracted from patient charts.[42] Group comparisons pre- and postimplementation were completed using chi-square or *t* tests as appropriate. Descriptive statistics and analyses were completed using SAS Enterprise Guide 5.1 running SAS 9.2.[a]

Results

Demographics

Cohort demographics are summarized in table 1. Sex distribution was comparable across sites (range of 66%-73% men). Mean age was 53 years with PI-SJHC having a higher mean age (57y) and FMC having a lower mean age (49y) compared to other sites ($P<.05$). There was moderate variation in the proportion of traumatic SCIs (range 33%-60%) and complete injuries (range 13%-28%); however, the proportion of individuals with paraplegia was comparable (range 51%-56%). Mean length of stay was 65 days (range 52-75), with PI-SJHC having a significantly shorter stay than all sites except GRH. Mean SCIPUS scores (range 8.3-9.3) and Braden scores (range 15.9-17.7) were similar across sites.

Sex proportions were similar preimplementation (73% men) and postimplementation (68% men). Pre- and postimplementation differences were observed for proportions of paraplegia (47% vs 55%) [$\chi^2(1, n=1723)=4.31$; $P<.05$], traumatic injuries (52% vs 43%) [$\chi^2(1, n=1855)=5.62$; $P<.05$], and complete injuries (31% vs 15%) [$\chi^2(1, n=1693)=25.57$; $P<.05$]. For sites using the Braden, there were no differences in scores from pre- to postimplementation.

Best practice implementation

Pre- and postimplementation completion rates for the SCIPUS and Braden were evaluated (supplemental fig S1, available online only at http://www.archives-pmr.org/). Overall risk assessment completion rates improved from pre- (45.7%) to postimplementation (93.7%) [$\chi^2(1, n=2371)=5425$; $P<.05$]. Postimplementation completion rates were higher for the Braden (98.6%) compared to the SCIPUS (91.8%) [$\chi^2(1, n=2030)=31.5$; $P<.05$]. Neither the SCIPUS nor Braden completion rates and scores changed from initial to full implementation ($P>.05$).

Completion rates increased for the implemented interprofessional PI best practices from initial to full implementation (supplemental fig S2, available online only at http://www.archives-pmr.org/). Completion of interprofessional risk factor determination improved from 30% to 37% [$\chi^2=(1, n=1751)=11.94$; $P<.05$], whereas completion of the interprofessional prevention plans increased from 23% to 29% [$\chi^2=(1, n=1752)=6.62$; $P<.05$]. When considering both partial and late completion, interprofessional risk factor determination completion rates improved from 67% to 96% [$\chi^2=(1, n=1751)=272.94$; $P<.05$], whereas completion of interprofessional prevention plans improved from 67% to 94% [$\chi^2=(1, n=1752)=230.15$; $P<.05$].

The available documentation of educational practices suggested an increase from preimplementation to full implementation in the delivery of educational materials (42% to 74%) [χ^2 (1, n=1091) =52.56; $P<.05$] and unstructured individualized education (69% to 83%) [χ^2 (1, n=1198)=19.71; $P<.05$], but not for attendance to structured class-based education (43% vs 50%; $P>.05$) (see supplemental fig S2). When considering the provision of at least 1 type of patient education, there was an increase from 71% to 86% preimplementation to full implementation [χ^2 (1, n=1238)=30.18; $P<.05$]. Responses to patient surveys (table 2) revealed significant improvements from initial to full implementation for 2 of 4 items—receiving information and learning skills about skin care that were right for them [$F_{1,523}=4.79$; $P<.05$) and in a format that met their needs [$F_{1,520}=3.44$; $P<.05$]. No differences were found for the other survey questions ($P>.05$).

Pressure injury incidence and prevalence

PI incidence and prevalence data are summarized in table 3. A total of 1236 PIs were documented in 719 patients (30.3%) with 219 patients (9.2%) having >1 PI. At rehabilitation admission, 533 patients (22.5%) had PIs, whereas 328 patients (13.8%) developed PIs during rehabilitation. The incidence of stage 2 or

Table 2 Patient Education Survey results for initial and full implementation periods

Survey Question	Initial	Full	n
I received information and learned skills about skin care that are right for me.	3.37 (0.85)	3.52 (0.75)*	523
I understood the information about skin care that was provided to me.	3.48 (0.78)	3.56 (0.72)	521
The way I received information and learned skills met my needs (eg, group classes, written material, individualized teaching).	3.41 (0.81)	3.56 (0.69)*	520
I will use the skills and information about skin care in my daily life.	3.51 (0.73)	3.62 (0.67)	523

NOTE. Patients responded at discharge to each question on a 5-point Likert scale of 0-4, where 0 indicated completely disagree and 4 indicated completely agree. Data are presented as: mean (SD).
* Denotes significant difference.

greater PIs during rehabilitation was 7.2% (n=66). Including PIs present at admission, 21% of patients had at least 1 stage 2 or greater PI during rehabilitation. The anatomical distribution of observed PIs is provided in table 4. PIs typically involved the lower body with the buttocks, coccyx, and sacrum accounting for 53.5% of observed PIs. The next most common location was the heel (15.4%). Most PIs involved the midline (44.9%) with no differences in PIs on the left (26.3%) versus the right side (26%). The change in PI incidence pre- to postimplementation was not statistically significant for PIs of any stage (17% vs 13.3%) [χ^2 (1, n=2371)=3.21; P>.05] or PIs stage 2 or greater (7.0% vs 7.2%) [χ^2 (1, n=2371)=0.01; P>.05].

Discussion

The SCI KMN is a pan-Canadian initiative currently consisting of 7 SCI inpatient rehabilitation programs, 6 programs at the time of data collection. Participating sites worked collaboratively to improve and harmonize care to individuals participating in SCI inpatient rehabilitation in Canada. Here we describe our experience and outcomes related to implementing identified practices across sites in a standardized fashion, supported by the theoretical framework of the emerging discipline of implementation science. The initial area of focus was PI prevention, which was an identified priority of the funders. Two of the following best practices were identified and selected for implementation: (1) completion of a PI risk assessment instrument followed by the completion of an interdisciplinary risk factor determination and prevention plan; and (2) provision of PI prevention education to patients. The objective was to implement and ensure the consistent performance of the selected practices across participating sites.

The outcomes of the 4-year initiative are described for 2371 individuals participating in SCI inpatient rehabilitation. The 6 participating sites differed in size, unit type (dedicated SCI vs mixed neurorehabilitation), and some demographic variables (see table 1). There were, however, no intersite differences for mean Braden and SCIPUS scores, suggesting a comparable PI risk at rehabilitation admission. Interestingly, patient demographics differed between pre- (2011-2012) and postimplementation (2012-2015) cohorts. Postimplementation, patients were more likely to be paraplegic, nontraumatic, and incomplete. These differences may be due to the changing demographics of SCI in Canada, with nontraumatic and incomplete SCI becoming increasingly common.[38] Despite these differences, PI risk (reflected by Braden scores) and incidence was similar pre- and postimplementation.

Injury completeness is a known PI risk factor.[28,43,44] With the postimplementation cohort having fewer individuals with complete injuries compared to the preimplementation cohort (15% vs 31%), a lower incidence rate may have been expected in the absence of practice change. Despite this, incidence remained unchanged. Similarly, an increased incidence of paraplegia might be expected to decrease PI incidence due to increased mobility associated with preserved upper extremity function.

Best practice implementation

As discussed in the introduction, there are considerable challenges associated with translating and implementing practices in the clinical realm, particularly when the desired scale involves

Table 3 PI incidence and prevalence

n=2371	Admission (% of Patients)	Admission (No. of PIs)	Incidence (% of Patients)	Incidence (No. of PIs)	Prevalence (% of Patients)	Prevalence (No. of PIs)
Stage 1	4.9	140	7.0	215	10.6	337
Stage 2	11.9	354	6.5	213	16.9	571
Stage 3	2.2	58	0.4	11	2.9	76
Stage 4	1.7	40	0.0	1	2.0	51
Unstageable	1.3	38	0.1	2	0.4	12
DTI	0.8	19	0.5	14	1.4	37
Unknown	2.9	92	1.2	39	4.2	152
Any stage	22.5	741	13.8	495	30.3	1236
Stage≥2	16.2	601	7.2	280	21.0	899

NOTE. Prevalence was defined as individuals with a PI present at any time point during rehabilitation. Incidence was defined as the development of a new PI during rehabilitation, regardless of whether the individual already had a PI at admission. Stage≥2 indicates patients who had at least 1 PI of stage 2 or greater (including unstageable and DTI, but not unknown).
Abbreviation: DTI, deep tissue injury.

Table 4 Anatomical distribution of pressure injuries observed during SCI rehabilitation

Lower Core		Lower Extremity	
Buttocks	206 (16.7)	Foot (nonspecific)	69 (5.6)
Gluteal fold	55 (4.4)	Heel	190 (15.4)
Coccyx	258 (20.9)	Ankle	39 (3.2)
Sacrum	196 (15.9)	Lower leg	20 (1.6)
Genitals	10 (0.81)	Knee	14 (1.1)
Groin	14 (1.1)	Thigh	28 (2.3)
Anus	3 (0.24)	Hip	16 (1.3)
Upper Core		**Upper Extremity**	
Back	20 (1.6)	Hand (nonspecific)	4 (0.32)
Scapula	6 (0.49)	Wrist	2 (0.16)
Abdomen	6 (0.49)	Elbow	25 (2)
Breast/chest	14 (1.1)	Armpit	2 (0.16)
Neck	3 (0.24)	Arm	2 (0.16)
Head	26 (2.1)	Shoulder	1 (0.08)

NOTE. Data are presented as n (%). The locations of 7 pressure injuries were unknown.

multiple sites and environments. Outcomes for key process indicators suggest that the application of implementation science and accompanying Active Implementation Frameworks led to meaningful improvements in the completion of targeted practices at participating SCI KMN sites. The use of structured approaches to implementation, with sound theoretical underpinnings, can therefore play an important role in promoting the adoption of desired practices in the clinical context with the desired fidelity. Frameworks, such as the one advocated for by NIRN, systematically address barriers and identify facilitators for successful best practice implementation. Other frameworks explored by the SCI KMN included Consolidated Framework for Implementation Research,[14] Promoting Action on Research Implementation in Health Sciences,[45] Knowledge to Action,[46] and Lean.[47]

After implementation, there was a substantial improvement in risk assessment instrument completion rates (see supplemental fig S1). Preimplementation, PI risk assessment instruments were completed for less than half of admitted patients despite being required hospital policy at all sites. Postimplementation completion rates were lower for the SCIPUS compared to Braden (92% vs 99%), which is likely attributable to the fact that the SCIPUS requires laboratory results for completion. The SCIPUS was also a new instrument which required training for completion, in contrast to the Braden with which clinical staff were already familiar.

Multiple best practice guidelines recommend interprofessional approaches to PI prevention and treatment.[35-37] Compared to completion of the risk assessment instruments (Braden or SCIPUS), ensuring completion of the interprofessional risk factor determination and prevention plan was a challenge. Prevention plans were considered interprofessional when completed by at least 4 professions. Although completion rates increased from 30% to 37% for high-risk individuals from initial to full implementation, absolute rates remained low. Prevention plans were not performed preimplementation. The primary barrier was the requirement for 4 or 5 individuals (disciplines) to contribute to the plan. When the criteria for completion were loosened to accommodate fewer than 4 professions (partially complete) or late completions (>10d), completion rates improved from initial to full implementation for both interprofessional risk factor determinations (67% to 96%) and prevention plans (67% to 94%). It should also be acknowledged that achieving true interprofessional collaboration is a challenge. The true process may have been better characterized as multidisciplinary (individuals of different disciplines determining actionable strategies) than interprofessional (a collaborative team of members with different expertise determining an overarching plan).

Available documentation also suggested that patient education was enhanced. From preimplementation to full implementation, the documented provision of educational materials (42% to 74%) as well as individualized one-on-one education (69% to 83%) increased, but not class attendance (see supplemental fig S2). Overall, the documentation of at least 1 educational activity increased preimplementation to full implementation (71% to 86%). Postimplementation documentation of patient education did include additional sources (eg, discharge patient survey), which could have artificially inflated numbers. Practice change may have been reflected by small but significant improvements (initial to full implementation) in patient responses to survey items which addressed whether personalized information about PI prevention was provided in a format that met patient needs (see table 2). Ceiling effects (satisfaction scale from 0 to 4) may have masked changes for other survey items, particularly given that participants were generally positive during initial implementation.

PI incidence and prevalence

Although the primary intent of the SCI KMN initiative was to implement identified best practices (and related processes) at participating sites in harmonized fashion, data were collected on the related secondary outcomes of PI incidence and prevalence. Not surprisingly, PIs were a common occurrence at participating SCI KMN sites. At admission, 22% of individuals had PIs and an additional 14% developed new PIs during rehabilitation, with an overall prevalence of 30% (see table 3). When limited to PIs of stage 2 or greater, incidence was 7% and prevalence was 21%. Previous studies reported similar findings for acute and rehabilitation SCI settings.[48-52] The coccyx, buttocks, sacrum, and heels were the most common locations for PI development, together comprising two-thirds of observed PIs (see table 4). These are commonly reported sites for PI development after SCI.[48-51] The remaining PIs were distributed in small percentages over 18 additional anatomical locations. The large cohort size provided a more representative distribution for infrequently cited PI locations, compared to smaller studies.

Despite improved completion rates for PI risk assessment and prevention plans, the reduction in PI incidence from pre- to postimplementation cohorts was not statistically significant. Although a documented reduction in PI incidence would have been ideal, this was not a clinical trial designed specifically to achieve this outcome. Regardless, several factors could have contributed to this. The content of prevention plans was largely left to the discretion of treating teams, although there was a general expectation that risk factors identified in the prevention plan would be addressed. In addition, there was also an absence of audits to document compliance with actionable items identified in prevention plans. There is also the possibility that focused implementation efforts may have increased awareness, accountability, and documentation of PIs, resulting in increased reporting over the implementation period. Finally, as recognized SCI rehabilitation centers, participating sites had experience working with individuals with SCI and PI prevention practices were already in place. Although risk assessment and prevention plan formulation are important processes to incorporate into inpatient SCI rehabilitation, the results of the SCI KMN suggest that additional targeted interventions will be required to reduce PI incidence.

It is also important to acknowledge that there is still very little Level I evidence (randomized trials) supporting the efficacy of interventions targeting PI prevention in SCI.[36] The SCI KMN considered 48 candidate best practices for implementation.[18] After a consensus building process, the best practices selected for implementation had the following evidence levels for PI prevention[36]: complete a structured risk assessment instrument: Level IIa evidence (controlled study); complete an individualized, interprofessional risk assessment and prevention plan: Level IV evidence (expert opinion); and provide structured and individualized PI prevention education to patients: Level III evidence (descriptive study).

Although these practices have been recommended by guidelines, a direct link has yet to be demonstrated between these practices and PI incidence in SCI rehabilitation. In addition, it has become increasingly apparent that the SCIPUS may have significant limitations in the context of SCI.[53,54] Moreover, although the delivery of patient education is a central and essential component of inpatient SCI rehabilitation, its effect on PI incidence might not be apparent until after community reintegration when individuals with SCI are responsible for managing their own care. The work reported here highlights the continued need to strengthen the evidence base underpinning practice guidelines.

Building implementation capacity

An important secondary goal of the SCI KMN was the development of implementation capacity, which could be applied to additional activities in the future. Because each site implemented required PI practices, activities were leveraged to enhance implementation capacity for related work (supplemental table S1, available online only at http://www.archives-pmr.org/). The expertise developed with PI practices was also applied to the implementation of best practices in pain management after SCI and shared with a new SCI KMN site, the Stan Cassidy Centre for Rehabilitation, Fredericton, New Brunswick, which joined the network in 2015.

Study limitations

Implementing best practices across 6 different rehabilitation sites using Active Implementation Frameworks required establishing core components for implementation while allowing sufficient variation to address site-specific capacity and barriers. Customization to the local context was necessary to achieve sustainable implementation; however, this created challenges for across-site evaluation. Despite these limitations, the inclusion of multiple sites, with the accompanying variation, enhances generalizability to other settings considering the implementation of similar practices.

Study data were extracted from health records after discharge, and thus was dependent on the accuracy of clinical documentation, which in turn could contribute to underreporting. Furthermore, this study assessed the completion of a prevention plan at admission; however, day-to-day execution of the prevention plan was not measured. This will be an important consideration for future studies of this nature.

Conclusions

PI prevention best practices were successfully implemented in 6 SCI inpatient rehabilitation sites participating in the SCI KMN. This was evident in a sustained increase in completion rates for structured risk assessment instruments, as well as interprofessional risk factor determination and accompanying prevention plans at admission to SCI. The rates of and satisfaction with provision of patient education also increased over a 4-year period. Despite these improvements, there was no significant reduction in PI incidence pre- to postimplementation. The experience of the SCI KMN suggest that broad scale implementation of targeted practices can be enhanced through the use of structured implementation frameworks, with strong theoretical underpinnings. Affecting specific outcomes such as PI incidence, however, will require additional interventions. Results from this study highlight an ongoing need to strengthen the evidence base underpinning practice guidelines.

Supplier

a. SAS 9.2; SAS Institute Inc.

Keywords

Evidence-based practice; Pressure ulcer; Rehabilitation; Spinal cord injury; Translational research

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