

## REVIEW

# Knowledge translation and implementation in spinal cord injury: a systematic review

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**Objective:** To conduct a systematic review examining the effectiveness of knowledge translation (KT) interventions in changing clinical practice and patient outcomes.

**Methods:** MEDLINE/PubMed, CINAHL, EMBASE and PsycINFO were searched for studies published from January 1980 to July 2012 that reported and evaluated an implemented KT intervention in spinal cord injury (SCI) care. We reviewed and summarized results from studies that documented the implemented KT intervention, its impact on changing clinician behavior and patient outcomes as well as the facilitators and barriers encountered during the implementation.

**Results:** A total of 13 articles featuring 10 studies were selected and abstracted from 4650 identified articles. KT interventions included developing and implementing patient care protocols, providing clinician education and incorporating outcome measures into clinical practice. The methods (or drivers) to facilitate the implementation included organizing training sessions for clinical staff, introducing computerized reminders and involving organizational leaders. The methodological quality of studies was mostly poor. Only 3 out of 10 studies evaluated the success of the implementation using statistical analyses, and all 3 reported significant behavior change. Out of the 10 studies, 6 evaluated the effect of the implementation on patient outcomes using statistical analyses, with 4 reporting significant improvements. The commonly cited facilitators and barriers were communication and resources, respectively.

**Conclusion:** The field of KT in SCI is in its infancy with only a few relevant publications. However, there is some evidence that KT interventions may change clinician behavior and improve patient outcomes. Future studies should ensure rigorous study methods are used to evaluate KT interventions.

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## INTRODUCTION

Challenges in translating research evidence into the clinical setting are well known. It has been reported that only 14% of research is translated into practice and it takes an average of 17 years for this to occur.<sup>1,2</sup> Frequently reported barriers in moving evidence into practice include limited time, expertise, administrative support and resources.<sup>3,4</sup>

To overcome these barriers, Fixsen *et al.*<sup>5</sup> (part of the National Implementation Research Network (NIRN)) describe three approaches in translating knowledge first in fields such as education and now in health care. The first is a passive approach referred to as ‘letting it happen’, whereby research findings are only published (diffusion); the second involves providing aids, such as toolkits, ‘helping it happen’ (dissemination); and finally, the most active approach involves focusing on the implementation process to ensure the environment supports ‘making it happen’ (implementation).<sup>5</sup> Various implementation frameworks have identified methods to assist with the implementation, also known as key ‘drivers’ of effective implementation, that consider intervention characteristics, external and internal environments, participants and the active change process of implementation.<sup>5</sup>

Similarly, the ‘Knowledge to Action’ cycle proposed by Graham *et al.*<sup>6</sup> differentiates knowledge creation (studies, toolkits) from the

action cycle (application of knowledge) and outlines the relationship among the action phases within the cycle. Furthermore, the National Institutes of Health (NIH) Roadmap expands the process of moving new innovations into practice by describing the additional research laboratory of practice-based research as the needed translational step to improve incorporation of discoveries into the front line of clinical care.<sup>7</sup>

In the field of spinal cord injury (SCI), the literature reports variability in all aspects of care, including acute clinical care,<sup>8</sup> the management of chronic pain<sup>9</sup> as well as expectations regarding outcomes given by clinicians to patients.<sup>10</sup> There are multiple challenges in a field such as SCI to identify and implement evidence-based practices. Randomized controlled trials (RCTs) are required to generate level 1 evidence, but are often difficult to implement in clinical practice, do not often produce generalizable results and may preclude some people with SCI from receiving innovative therapies.<sup>11</sup> Various strategies have been developed to summarize the body of evidence available and to assist with translating existing evidence into the clinical setting. The Spinal Cord Injury Rehabilitation Evidence (SCIRE) Project synthesizes research evidence on rehabilitation practices to inform health-care professionals, scientists, policymakers and consumers with SCI.<sup>12</sup> The Consortium for Spinal Cord Medicine also synthesizes research

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evidence and has developed clinical practice guidelines and consumer guides.<sup>13</sup> Guidelines and evidence syntheses provide platforms upon which knowledge translation (KT) interventions can be built. In other words, they ‘let’ and ‘help’ KT to happen but do not ‘make’ it happen. The SCI Quality Enhancement Research Initiative (QUERI) takes KT a step further by striving to ‘make’ it happen by systematically implementing clinical research evidence into practice to enhance the quality of care and outcomes.<sup>14</sup> Even with the development of these and other interventions to disseminate and implement best practice in order to improve patient care, there is a need to examine whether KT interventions have affected outcomes—whether KT ‘happened’ and if so, was it effective.

In this study we will refer to KT interventions as factors used to assist the process of implementing practice change as well as the targeted practice itself. The objective of this study was to conduct a systematic review of the literature that evaluates original research publications on KT interventions used throughout the SCI continuum of care (prehospital through community) and to determine the effect of the implementation on practice through clinician behavior change and the impact on patient outcomes.

## MATERIALS AND METHODS

### Search strategy

A preliminary PubMed search was conducted to ensure there were no other published systematic reviews on this topic. A protocol was developed after consultation with a research librarian. Four electronic databases, MEDLINE (1946–present; OvidSP), PubMed (1946–present; PubMed), CINAHL (1982–present; EBSCOhost), EMBASE (1974–present; OvidSP) and PsycINFO (1887–present; EBSCOhost) were searched for English studies published from January 1980 to July 2012. The search strategy was based on previously published protocols.<sup>15</sup> Search terms related to SCI, such as ‘spinal cord injury’ or ‘tetraplegia’, were combined with search terms related to KT, such as ‘knowledge translation’ or ‘implementation’, to generate a broad list of articles. The terms were searched both as subject headings and as keywords (see Supplementary File 1). No additional searching from nonelectronic sources was done.

### Article selection

All articles identified from the search strategy were imported into the reference software RefWorks and duplicates were removed. Two reviewers (VKN and SEP) examined the article titles and a list of relevant articles was generated. The same two reviewers then independently screened the abstracts for inclusion and consensus was obtained in cases where there was a disagreement. Finally, full articles were acquired and independently reviewed for inclusion by the same two reviewers. Any duplicates not identified by RefWorks were manually removed during the abstract and full article review.

The study inclusion criteria were: (1) the article described the process for implementing a KT intervention and the methodology for evaluating the implementation (actively implementing research evidence into practice); (2) the KT intervention targeted patients with either a traumatic or nontraumatic SCI; (3) the KT intervention was related to clinical practice or education in any phase of the continuum (prehospital, acute, rehabilitation, community); and (4) the article was original research written in English and published between January 1980 and July 2012.

The study exclusion criteria were: (1) the article described the development of a clinical tool or measure (for example, clinical practice guideline or outcome measure) but did not describe the implementation; (2) the article described the impact on patient outcomes but did not describe the implementation; (3) less than half of the sample was individuals with SCI or the study had a sample size less than three subjects; or (4) unpublished materials. Included studies had to describe the methodology used to evaluate the implementation process but did not have to include methodology used to evaluate the effect on patient outcomes, as the main focus of the study was on the former. To capture all relevant studies examining implementation related

to SCI across the continuum of care, no articles were excluded based on study design or phase of care.

### Data abstraction

Studies included in the final selection were abstracted by one of the reviewers (SEP) and verified by the other (VKN). The data abstraction form was developed by modifying an example provided by Scott *et al.*<sup>15</sup> in their previously published protocol (Supplementary File 2). For all studies, data abstracted included describing (1) the study (setting, location, design, number of sites involved); (2) the sample (sample size, inclusion/exclusion criteria); (3) KT intervention and hypothesized outcome; (4) KT implementation methods (deliverer of KT intervention, evidence supporting its uptake, strategies used for implementation); and (5) the evaluation of the clinician behavior change and effect on patient outcome (description of evaluation procedure for implementation, outcome measures used, facilitators/barriers to implementation). No attempt to contact original study authors was made to obtain missing information.

### Study quality rating

Study quality rating was independently assigned by two raters (NPT and SEP) using the Downs and Black checklist<sup>16</sup> that assesses the study reporting quality, external validity, internal validity (bias and confounding) and power. The last item on the Downs and Black checklist, related to the power calculation, was modified. Rather than providing a score from 0 to 5, a score of 1 was assigned to studies that included a power calculation and a score of 0 was given to studies without any power calculation. This resulted in a maximum score of 28 instead of 32. A higher score reflects a more thorough reporting of results and more rigorous study methodology. Downs and Black score ranges were grouped into the following four quality levels according to the range suggested by Samoocha *et al.*:<sup>17</sup> excellent (26–28), good (20–25), fair (15–19) and poor ( $\leq 14$ ). Consensus among the raters was obtained when there

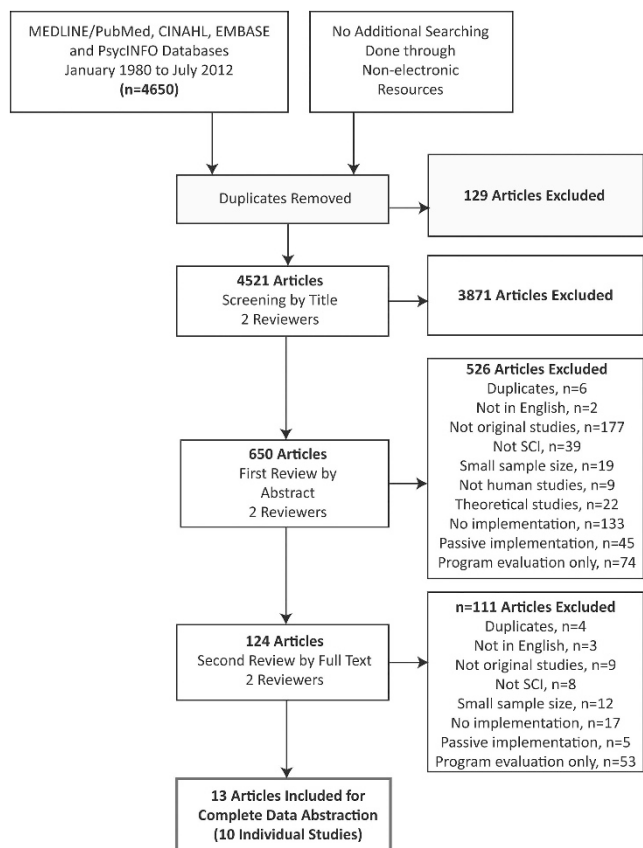


Figure 1 Flow diagram of studies selected and included.

was a disagreement on ratings. In addition, based on the type of study design, raters assigned a level of reported evidence as per the methodology used by SCIRE.<sup>12</sup> Level 1 evidence reflects the strongest evidence and includes high-quality RCTs. Conversely, level 5 is the lowest score for evidence, based solely on expert opinion, a case report or an observational study.

## RESULTS

The initial search identified 4650 articles. Following the reviews based on the title, abstract and full text, 13 articles<sup>18–30</sup> related to 10 studies were included (see Figure 1). The articles included were published in a variety of journals; 7 of the 13 articles were published in the *SCI* journal<sup>20,21,23,26,28–30</sup> and the remainder were published in rehabilitation ( $n = 3$ )<sup>18,19,22</sup> or other types ( $n = 3$ ) (for example, Implementation Science).<sup>24,25,27</sup>

An overview of the 10 studies is provided in Table 1. The studies were conducted primarily in the United States ( $n = 5$ )<sup>20,21,23,26–28</sup> and within the acute phase of care ( $n = 4$ ).<sup>21,25,26,29</sup> Most studies used a pre-post design ( $n = 8$ )<sup>21–26,28,29</sup> that resulted in level 4 evidence. The Downs and Black score ranged between 3 and 19, with a median rating of 12. The majority of 13 articles were classified as ‘poor’ with a rating of  $\leq 14$ .<sup>18–25,27,29</sup> There were two articles considered to be ‘fair’,<sup>26,28</sup> but none were considered ‘good’ or ‘excellent’.

An overview of the KT intervention for each of the 10 studies is outlined in Table 2. The interventions all targeted clinician behavior and are classified into three categories based on the overall goal of the KT intervention; seven studies developed and implemented a patient care protocol that was not a current standard of care at their site,<sup>18,19,21,23–26,29</sup> two studies included a KT intervention to provide

**Table 1 Overview of studies**

Reference	Number of participants	Type of SCI included	Study setting	Type of study	Level of evidence and rating of study quality
18	134 Enrolled 134 Completed	ntSCI + tSCI	Outpatient rehab The Netherlands, national	Post test	Level 4 DB = 9
19	149 Enrolled 116 Completed	ntSCI + tSCI	Outpatient rehab The Netherlands, national	Cohort study	Level 2 DB = 12
20	95 Enrolled (clinicians) 95 Completed (clinicians)	NA	In-patient rehab USA, single center	Post test	Level 4 DB = 7
21	51 (Cohort 1), 37 (Cohort 2), 46 (Cohort 3) enrolled 51 (Cohort 1), 37 (Cohort 2), 46 (Cohort 3) completed	tSCI	Acute USA, national	Pre-post	Level 4 DB = 12
22	115 Enrolled 82 Completed	ntSCI + tSCI	In-patient rehab Netherlands, national	Pre-post	Level 4 DB = 13
23	4432 Enrolled 4432 Completed	ntSCI + tSCI	In-patient rehab USA, national	Pre-post	Level 4 DB = 11
24	NR (clinicians)	NA	All phases of care West Scotland, regional	Pre-post	Level 4 DB = 3
25	53 (Cohort 1), 95 (Cohort 2) enrolled 53 (Cohort 1), 95 (Cohort 2) completed	ntSCI	Acute UK, single center	Pre-post	Level 4 DB = 14
26	22 (Cohort 1), 36 (Cohort 2) enrolled 22 (Cohort 1), 36 (Cohort 2) completed	NR	Acute USA, single center	Pre-post	Level 4 DB = 16
27	3015 (Year 1), 3038 (Year 2) enrolled	ntSCI + tSCI	Community USA, national	Post test	Level 4 DB = 5
28	922 Completed (with both year 1 and 2 data)		Community USA, national	Pre-post	Level 4 DB = 19
29	76 (Cohort 1), 93 (Cohort 2) enrolled 76 (Cohort 1), 93 (Cohort 2) completed	tSCI	Acute Canada, single center	Pre-post	Level 4 DB = 14

Abbreviations: DB, Downs and Black study quality rating score; NA, not applicable; NR, not reported; ntSCI, nontraumatic spinal cord injury; tSCI, traumatic spinal cord injury. Reference 30 only cites facilitators and barriers related to references 21 and 23, and hence is only included in Table 5. Number of participants enrolled is the number at the beginning of the study. Number of participants completed is the number who remained until the study completion.

**Table 2 Overview of KT interventions**

Reference	Description of the KT intervention	Type	Type of evidence used to develop the KT intervention
18,19	The concept of transmural care was developed and implemented. A transmural nurse liaised people with SCI living in the community with primary care professionals and the rehab center to provide support and continuity of care.	Patient care	Multiple studies (no RCTs) Expert opinion
20	An educational KT intervention was developed and pilot tested where basic competencies, identified by the Clinical Coordination Committee to be necessary for the care of SCI, were either taught in classes or presented at a Competency Fair for staff.	Education	Joint Commission of Rehabilitation Facilities (JCAHO) Commission on Accreditation of Rehabilitation Facilities (CARF)
21	A Consortium for Spinal Cord Medicine clinical practice guideline for preventing thromboembolism in SCI, which includes administering appropriate pharmacologic prophylaxis to the appropriate individuals for appropriate duration, was implemented.	Patient care	Clinical practice guideline(s) Multiple studies (includes RCT)
22	'Patient monitoring' project implemented a set of seven tests (e.g. wheelchair skills, physical capacity, muscle strength, etc) that measured body function and activity using ICF levels to systematically monitor functional progress of patients during rehab.	Outcome measure	Outcome measures with established psychometric properties
23	A Consortium for Spinal Cord Medicine clinical practice guideline for neurogenic bowel management in SCI, which includes thorough documentation of functional assessments, patient education and colorectal cancer screening, was implemented.	Patient care	Clinical practice guideline(s) Expert opinion
24	MSCC clinical guideline was developed and disseminated via local board implementation groups to decrease the time from detection of MSCC to treatment. The guideline includes a list of key signs and symptoms, as well as a screening and treatment protocol for suspected MSCC.	Patient care	Multiple studies (no RCTs) Expert opinion
25	A care pathway was developed and implemented to standardize the way patients with spinal cord compressions are managed; specifically, to identify patients who are ready to be mobilized or require surgery and decrease the risk of complication as a result of flatbed rest.	Patient care	Multiple studies (no RCTs) Analyses or observation of own current practice Expert opinion A pilot study
26	A clinical pathway was developed and implemented to ensure all patients with cervical or high thoracic SCI admitted to the ICU received standardized treatment according to clinical practice guidelines and best available evidence.	Patient care	Clinical practice guideline(s) Multiple studies (no RCTs)
27,28	A mail campaign was initiated to send individuals with SCI living in the community and health-care providers at SCI centers reminders encouraging vaccinations and emphasizing the benefit. A computerized reminder system and standing order were also implemented in the centers to remind the health-care professionals of the vaccination. Used QUERI implementation approach.	Education	Recommendations by expert panel Multiple studies (no RCTs)
29	A multi-disciplinary care team for patients with acute SCI was formed to improve patient care. The team met weekly to discuss patient cases, develop order forms, protocols and a handbook for patients and families containing relevant information about spine, spinal cord, treatment, support groups and different hospital wards.	Patient care	Systematic review/meta-analysis Multiple studies (no RCTs)

Abbreviations: ICF, International classification of Functioning, Disability and Health; ICU, intensive care unit; KT, knowledge translation; MSCC, Malignant Spinal Cord Compression; rehab, rehabilitation; SCI, spinal cord injury; SCI&D, spinal cord injury and disease; RCT, randomized controlled trial; QUERI, Quality Enhancement Research Initiative.

education<sup>20,27,28</sup> one study incorporated outcome measures into the clinical setting.<sup>22</sup> The KT methods used to assist implementation (drivers) included promoting clinician's competency in 6 studies,<sup>18–22,24,27,28</sup> using organizational strategies in all 10 studies,<sup>18–29</sup> and engaging the leadership in their organization in 5 studies<sup>20,21,24,27–29</sup> (see Table 3).

Evaluation of clinician behavior change and the effects on patient outcomes are described in Table 4. The drivers identified in Table 3 were not consistently evaluated (see Table 4). The methods used to evaluate changes in clinician behavior included auditing documents ( $n = 6/10$  studies),<sup>18,19,21,23,25,26,29</sup> conducting a self-reported survey of knowledge or change in practice based on the KT intervention ( $n = 5/$

10 studies)<sup>18–20,22,24,27,28</sup> and measuring attendance at training sessions ( $n = 1/10$  studies).<sup>20</sup> Only 3 out of 10 studies evaluated the clinician behavior change using statistical analyses; all 3 studies reported some significant changes.<sup>21,23,25</sup>

All studies except three evaluated the effect of the implementation on patient outcomes,<sup>18,19,21,22,25–29</sup> and six of these seven studies evaluated the effectiveness using statistical analyses.<sup>18,19,21,25–29</sup> Four studies reported statistically significant changes in patient outcomes;<sup>25–29</sup> the implementation of a pathway decreased in-patient mortality<sup>25</sup> and length of stay,<sup>26</sup> formation of a multidisciplinary team reduced length of stay and improved clinical care<sup>26,29</sup> and a campaign to raise awareness of the importance of

**Table 3 Knowledge translation (KT) methods (drivers) to assist with the implementation**

Drivers	Education program		Patient care protocol/program							Outcome measures
	References									
	20	27,28	18,19	21	23	24	25	26	29	22
<i>Competency drivers</i>										
Provider education and training	✓	✓				✓				✓
Ongoing coaching/feedback to personnel implementing intervention		✓	✓	✓						
Dissemination of educational materials	✓	✓	✓	✓		✓				✓
<i>Organization drivers</i>										
Development/revision of treatment protocols/algorithms computerized				✓	✓	✓				
Development/revision of treatment protocols/algorithms paper form				✓		✓				
Development/revision of treatment protocols/algorithms computerization unknown	✓						✓	✓		✓
Other reminders for health care professionals computerized		✓		✓						
Other reminders for health care professionals paper form				✓			✓			
Other reminders for health care professionals computerization unknown								✓		
Selection of relevant and reliable measures										✓
Formation of an 'implementation team'/working group	✓		✓	✓	✓	✓	✓	✓		
Develop policies/processes to support practice change		✓							✓	
Regular audit, meeting and feedback among implementation team members		✓		✓		✓	✓			✓
Obtain feedback from stakeholders and staff		✓		✓		✓				
Objectively communicate strengths/barriers (for example, up/down the organizational levels)		✓		✓	✓					
Others (for example, provide designated ward space)									✓	
<i>Leadership drivers</i>										
Organizational leaders provide specific guidance, are engaged, provide reasons for change	✓	✓		✓		✓				
Organizational leaders have convened groups to build consensus	✓					✓			✓	
Organizational leaders are actively involved in the implementation process	✓			✓		✓				

vaccination produced an increase in vaccination rates and the patients' perception of their importance.<sup>27,28</sup>

Barriers to implementation were reported in 5 of 10 studies<sup>18,19,21–23,27,28,30</sup> and facilitators to implementation were reported in 5 studies<sup>18,19,21–23,25,30</sup> (see Table 5). The most commonly reported barrier was lack of resources, and communication was the most frequently described facilitator, both of which were at the clinician level.

## DISCUSSION

To our knowledge, this is the first systematic review describing implementation in SCI care delivery. In comparison, research in health conditions such as cancer have conducted more reviews in this area<sup>31,32</sup> and have progressed to further synthesize implementation evidence in a systematic review of published reviews.<sup>31</sup> Although evidence pertaining to implementation of research in SCI is in its infancy, results from this systematic review of KT strategies in SCI suggest that it is an emerging area of research, as 12 of the 13 articles included were published after the year 2000.<sup>18–28,30</sup> In only one study an implementation intervention using the QUERI approach in the United States was described,<sup>27,28</sup> in only two studies clinical practice guidelines developed by the Consortium for Spinal Cord Medicine were implemented<sup>21,23</sup> and no one reported using evidence from SCIRE, which was less than expected. Implementation of the KT interventions occurred primarily in the acute<sup>21,25,26,29</sup> and the

rehabilitation phases.<sup>18–20,22,23</sup> It is interesting to note that none occurred in the prehospital phase, possibly because of SCI being included in general trauma studies in this phase of care or the lack of interest to conduct SCI-specific studies focusing on prehospital care.

It is difficult to compare the study quality of implementation studies in SCI with other health conditions because of the different rating scales used. In this review, study quality was evaluated using the Downs and Black checklist<sup>16</sup> as part of the SCIRE methodology, but this checklist was not commonly used in other reviews<sup>32–34</sup> and it is not specific to implementation science. According to the categorization proposed by Samoocha *et al.*,<sup>17</sup> the majority of the articles were considered to be poor (10 of 12 articles),<sup>18–25,27,29</sup> suggesting the need for more rigorous study methodology. In a broader systematic review examining KT strategies in allied health professions, Scott *et al.*<sup>35</sup> used a different quality assessment tool, but similarly found that studies were of low methodological quality. Therefore, low-quality rating appears to be a problem in not only SCI, but also in the KT field in general. It should be acknowledged that controlled studies involving the implementation of clinical practices are extremely difficult to conduct, both from ethical and logistical perspectives.

A recent review by Boaz *et al.*<sup>36</sup> recommended including only studies whose KT interventions are derived from evidence as this is a fundamental principle of evidence-based practice. Almost all of the studies included in this review implemented evidence based on multiple research studies and expert opinion.<sup>18–21,23–29</sup> Other than

**Table 4 Evaluation of KT interventions**

<i>Reference</i>	<i>Methodology to evaluate clinician behavior change</i>	<i>Clinician behavior change results</i>	<i>Methodology to evaluate patient outcomes</i>	<i>Patient outcome results</i>
18,19	Study document audit Team member interview Self-reported awareness of the KT intervention No statistical analysis	68.7% of patients were informed of the KT intervention 100% adherence to use of the assessment list 32% of all patients received >6 contacts (KT intervention recommended) whereas 43% of all patients received <4 Contents of the KT intervention not executed as intended in many instances	Self-reported quality of follow-up care experience Prevalence of UTI, pressure ulcers and the number of readmissions in the control and experimental groups Used statistical analyses	Quality of follow-up care experience not statistically significant The prevalence of pressure ulcers, UTIs and the number of readmissions were not statistically significant
20	Attendance at education fair Anonymous questionnaire after the fair asking about the usefulness of the KT intervention No statistical analysis	95/110 staff members attended the fair 80% of respondents said knowledge had increased because of the fair 65% stated they saw caregivers from other disciplines using info from fair 28% applied knowledge from other disciplines into their practice Most thought the fair was beneficial	NR	NR
21	Medical record audit Used statistical analyses	No statistical difference in duration of the prophylaxis use of compression device Statistically significant change in the type of medication used and increase in documentation of physical assessment Patient education improved with statistical significance between 2nd and 3rd cohort only Increasing trend in the protocol adherence rate reported (no statistical significance noted)	Pre-post comparison of DVT rate via medical record audit and prospective measurement Used statistical analyses	Diagnosis of DVT increased from across the cohorts, but the results were not statistically significant
22	Self-reported use of suggested test and perception of implementation extent No statistical analysis	Each study center implemented 3 to 7 of 8 tests over the study period Trend toward more centers taking on fuller implementation	Participants' responses about the role of each of the implemented tests No statistical analysis	Overall, participants thought the tests informed them about their function (67–100%), led to discussions with their therapists (33–96%) and were clear (95–100%) and easy to perform (81–100%) Little support for the tests leading to changes in rehabilitation (11–38%)
23	Medical record audit Used statistical analyses	Documentation was not statistically different for patient history, physical examination, functional assessment and bowel management education, or patient/caregiver competence in bowel management A statistically significant increase in bowel care program documentation was reported	Pre-post comparison of neurogenic bowel management adverse events proposed but not completed No statistical analysis	NR
24	Staff questionnaire on the knowledge of MSCC and the clinical guideline No statistical analysis	Overall improvement in knowledge and practice (no numerical results reported)	NR	NR



Table 4 (Continued)

Reference	Methodology to evaluate clinician behavior change	Clinician behavior change results	Methodology to evaluate patient outcomes	Patient outcome results
25	Medical record audit Used statistical analyses	Statistically significant reduction of the proportion of patients being nursed flat	Medical record audit Used statistical analyses	Reduction of respiratory infections was not statistically significant Statistically significant decrease in in-patient death Survival rates at 78 weeks showed no statistically significant difference
26	Medical record audit No statistical analysis	3/39 patients were not treated according to the clinical pathway after its implementation	Pneumonia, pressure ulcers, LOS, ventilator days and total cost reduction per patient compared before and after implementation Used statistical analyses	No statistically significant difference between cohorts for total episode of pneumonia, average pneumonia episode and incidence of pressure ulcers Statistically significant improvement in LOS and ventilator days Total cost reduction per patient was \$21 881 (no statistical significance reported)
27,28	Reports from the staff Staff questionnaire E-survey of IT personnel Semistructured interviews with staff Follow-up interviews No statistical analysis	E-survey and interview result showed that there are variations in staff access to CCR There were 2 sites without a standing order policy	Self-reported vaccination rates and patients' change in attitude Used statistical analyses	Statistically significant increase in vaccination rates for entire sample Statistically significant increase in participants' perception of vaccination importance
29	Medical record audit No statistical analysis	Increase in the number of notes for respiratory technicians, social work, OT and nutritional services	Compared treatment-related factors Used statistical analyses	Statistically significant reduction in LOS of survivors and average days febrile Statistically significant increase in stabilization procedures and a decrease in surgical decompressions and tracheostomies

Abbreviations: CCR, computerized clinical reminders; DVT, deep vein thrombosis; IT, informational technology; KT, knowledge translation; LOS, length of stay; MSCC, Malignant Spinal Cord Compression; NR, not reported; OT, occupational therapist; SCI, spinal cord injury; UTI, urinary tract infection.  
The results were statistically significant if  $P < 0.05$ .

the clinical practice guidelines<sup>21,23,26</sup> or accreditation standards,<sup>20</sup> which might have proposed recommendations based on RCT-generated evidences, it was interesting that only one appeared to cite evidence from RCTs.<sup>21</sup> A best practice that is amenable to a RCT may not be appropriate for an individual clinical setting where there is need for initial implementation of more basic best practices. As well, resource availability may not allow for RCT-validated best practices that may involve costly equipment and/or staff training. The decision to implement evidence into practice should also consider factors such as feasibility, relevance to practice and impact on patient outcomes, but these factors are often overlooked and not consistently evaluated. Development of criteria for conducting and reporting implementation studies would enable study results to be compared within the same health condition, such as SCI, and across different types of health conditions.

In terms of the evidence generated from the implementation efforts included in this review, most of the studies produced level 4 evidence,<sup>18,20–29</sup> and there were no RCTs to generate level 1 evidence. This is not surprising as there are ethical obligations to provide all patients with the best practice care, making it challenging to conduct RCTs. In addition, the usefulness of the RCT in evaluating KT interventions has been questioned because of the often highly complex nature of KT interventions,<sup>37,38</sup> the risk of contamination of the intervention and control groups<sup>37</sup> and the expense.<sup>37</sup>

However, it has been suggested that to ensure the robustness of the results, researchers should consider using time series designs, action research, detailed case series and controlled before and after studies as alternatives to RCTs.<sup>38</sup> Given the complexity of KT intervention studies, the traditional levels of evidence may not apply and a greater focus should be on the quality of the study methodology.

Drivers used to execute the implementation efforts included targeting clinician competency, organizational structure and leadership in 4 of the 10 studies.<sup>20,21,24,27,28</sup> In contrast, 3 of the 10 studies<sup>23,25,26</sup> only addressed organizational drivers. All studies used multiple implementation drivers.<sup>18–29</sup> In the literature, the effectiveness of changing clinicians' behavior with single versus multiple drivers is not well defined.<sup>36,39</sup> Among the studies included in this review, studies that succeeded in changing clinician behavior did not necessarily utilize a greater number of drivers. In addition, it was not possible to ascertain the effectiveness of the individual drivers based on the studies included in this review, as it is often a set of drivers chosen based on a local context that become integrated and complement each other that determine the success of an implementation.<sup>5</sup> However, facilitators and barriers to implementation were noted.

The most commonly reported facilitator was communication within study groups.<sup>18,19,22,25</sup> This was as expected, because

**Table 5 Barriers and facilitators of implementing knowledge translation (KT) interventions**

<i>Types of facilitators</i>	<i>List of common facilitators</i>	<i>Studies reporting the facilitator</i>
<i>Facilitators</i>		
Communication	Presence of a team member who acted as a liaison among the team	18,19,22,25
	Consensus that the KT intervention in question will improve care	22
	Regular team meetings	18,19
	Stakeholder engagement before the implementation to get buy-ins and identify facilitators and barriers	21,23,30
	Continued training through ongoing educational inservices and new employee orientation	21,23,30
	Strong leadership and support from administration and local champion	21,23,30
Study design	KT intervention was flexible enough to adapt to the wishes of stakeholders	22
	Tests required by the KT intervention were easy to follow	22
Resources (funding, personnel)	Had resources dedicated to the KT intervention	18,19,22
	Presence of a pre-existing program with a similar purpose (that is, Commission for Accreditation of Rehabilitation facilities (CARF))	23
<i>Type of barriers</i>	<i>List of common barriers</i>	<i>Studies reporting the barrier</i>
<i>Barriers</i>		
Resources (funding, personnel)	KT intervention required additional ability that staff did not have at the beginning of the implementation	18,19,27,28
	Structure in the system that made it difficult to carry out the KT intervention	18,19,21,23,27,28,30
	Lack of time staff had for the KT intervention	18,19,21,23,30
	Frequent changing of staff/procedure resulted in repeated program introduction	21,30
Communication	Lack of consensus from health practitioners on the effectiveness of the treatment	21,23,30
	Lack of specific guidance on how the KT intervention should be carried out	21,23,30
Study design	The KT intervention was difficult to carry out/took too much time/stressful for the patients	22,27,28

sufficient communication between team members needs to occur in order to ensure competency of its members and develop an effective team. It was surprising that no studies mentioned the importance of communicating with leaders in the organization, as this has been identified as a major facilitator in other studies.<sup>5</sup> In this review, all 10 studies reported evaluating clinician behavior change indicators; however, only 3 studies evaluated the results on changes in clinician behavior empirically and demonstrated improvements.<sup>21,23,25</sup> The lack of empirical evaluation makes it difficult to determine whether the changes were significant. Grimshaw *et al.*<sup>39</sup> suggested that the rationale for the selection of drivers as well as documentation of the contextual data pertaining to the implementation need to be included in implementation studies. Future studies should address these points and include the theoretical justification for selecting the drivers and the resources to ensure lessons learned can be applied to SCI and other health areas with complex multifaceted interventions.

The ultimate goal of any implementation is to improve patient outcomes. In this systematic review, 7 of the 10 studies evaluated changes in patient outcomes.<sup>18,19,21,22,25–29</sup> Patients acquiring new knowledge or changing attitude were most frequently reported.<sup>22,27,28</sup> None of the implemented practices were successful in reducing secondary complications such as deep vein thrombosis,<sup>21</sup> pressure ulcers<sup>18,19,26</sup> or pneumonia<sup>25,26</sup> that will be of interest to clinicians. The implementation of the clinical pathway for managing patients with cervical and thoracic SCI admitted to intensive care units significantly reduced length of stay and in-patient mortality without a reduction in secondary complications, suggesting the need for further studies to determine whether this was a result of methodological issues (for example, measures used and sample size) or the effectiveness of clinical pathways developed.<sup>26</sup> It is interesting

to note that only three studies evaluated the impact of the KT intervention using patient's self-reported outcomes, as this provides valuable information from the patients' perspective.<sup>18,19,22,27,28</sup> One study reported a significant increase in the self-reported vaccination rate and perception of vaccination importance,<sup>27,28</sup> whereas the other study reported no change in the quality of follow-up care received<sup>22</sup> or number of pressure ulcers or urinary tract infections based on self-reported outcome measures.<sup>18,19</sup> Using more rigorous study methods, adequate sample sizes, appropriate outcome measures that assess patient outcomes and proper statistical analyses (for example, adjust for potential confounders) to measure the impact will enable the KT intervention to be more effectively evaluated. Furthermore, many studies implemented the targeted practices in a single center,<sup>20,25,26,29</sup> future studies should include multiple centers to evaluate team functioning. This will also assist with subject recruitment and provide the statistical power needed to evaluate the study results. Currently, the level and amount of evidence required to support a full multicenter implementation of a KT intervention do not exist which makes it difficult to translate the findings from this review and enable clinicians or policy makers to use the results. This information would assist in knowing what KT interventions should be adopted in SCI care settings and would be relevant to other health conditions.

In considering the results from this systematic review, it is important to recognize the limitations. There is very little published in SCI examining implementation, and therefore the sample size was small, with only 13 articles and 10 studies meeting the inclusion criteria. The study had a narrow publication range from 1980 to 2012 and only included original studies. As KT in SCI is a new field, this study likely captures most relevant publications using this time frame and excluding publications from earlier years does not severely affect



the generalizability of the study result. Limiting the search to published studies may have an effect of inflating the overall quality of the studies and perhaps biasing our findings toward showing positive results, as such studies are more likely to be published, and thus included in this review. It could also result in the exclusion of ongoing projects studying the implementing of evidence into clinical practice that have not yet been published, thereby underestimating the amount of evidence available, or research done in this field. Even though this study used two independent raters and developed a protocol with inclusion/exclusion criteria, it was often difficult to classify studies as utilizing active implementation ('making it happen') as compared with more passive approaches ('helping it happen'). As there are no standardized terms used in the field of KT, it is possible that the search strategy did not include all relevant terms and may not have identified all eligible studies. The need for well-defined and standardized terms has been raised by McKibbin *et al.*,<sup>40</sup> who reported 100 different terms used within the field. Refinement in the terminology will improve the methodology of KT studies and the reporting of results in future studies. Despite these limitations, this review serves as a benchmark of the state of implementation in SCI. A current initiative, the Knowledge Mobilization Network has partnered with the NIRN to implement and evaluate pressure ulcer treatment guidelines.<sup>41</sup> Results from this project will provide important evidence concerning the process of implementation and the effectiveness of this process to affect patient and clinical outcomes. With the growing need to incorporate KT as part of funding applications, it will create awareness for the importance of this kind of research and help advance the field.

## CONCLUSION

This systematic review provides an overview of implementation research in SCI that will be of interest to clinicians and policy makers. A total of 13 articles reporting on 10 studies were included. Results from this review demonstrated promising results in both changing clinician behavior and having an impact on important patient outcomes, such as in-patient mortality. The results from this study urge future implementation efforts to include a theoretical justification for the KT intervention selected and to ensure rigorous study methods are used to evaluate the effectiveness of the implementation.

## DATA ARCHIVING

There were no data to deposit.

## CONFLICT OF INTEREST

VKN, SEP and NTP were employees of the Rick Hansen Institute at the time this manuscript was written. The other authors declare no conflict of interest.

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- 4 Copeland JM, Taylor WJ, Dean SG. Factors influencing the use of outcome measures for patients with low back pain: a survey of New Zealand physical therapists. *Phys Ther* 2008; **88**: 1492–1505.
- 5 Fixsen DL, Naom SF, Blase KA, Friedman RM, Wallace F. Implementation research: a synthesis of the literature. University of South Florida Louis de la Parte Florida Mental Health Institute, The National Implementation Research Network: Tampa, FL, 2005, pp 119.
- 6 Graham ID, Logan J, Harrison MB, Straus SE, Tetroe J, Caswell W *et al*. Lost in knowledge translation: time for a map? *J Contin Educ Health Prof* 2006; **26**: 13–24.
- 7 Westfall JM, Mold J, Fagnan L. Practice-based research—'Blue Highways' on the NIH roadmap. *JAMA* 2007; **297**: 403–406.
- 8 Wernle MC, Zoumprouli A, Sedgwick P, Papadopoulos MC. Variability in the treatment of acute spinal cord injury in the United Kingdom: results of a national survey. *J Neurotrauma* 2012; **29**: 880–888.
- 9 Ravenscroft A, Ahmed YS, Burnside IG. Chronic pain after spinal cord injury: a survey of practice in UK spinal injury units. *Spinal Cord* 1999; **37**: 25–28.
- 10 Davidson D, Noonan VK, Dvorak MF, Zhang H, Fisher CG. The impact of patient expectations on outcome following treatment for spinal trauma: Part 1: What are spine surgeons telling their patients? *Spine (Phila Pa 1976)* 2010; **35**: 1807–1811.
- 11 Kao LS, Aaron BC, Dellinger EP. Trials and tribulations: current challenges in conducting clinical trials. *Arch Surg* 2003; **138**: 59–62.
- 12 SCIRE (Spinal Cord Injury Rehabilitation Evidence). Monkey Hill Health Communications; 2010 [cited 16 September 2012]. Available from <http://www.scireproject.com>
- 13 The Consortium for Spinal Cord Medicine. Paralyzed Veterans of America; 2009 [cited 16 September 2012]. Available from <http://www.scicpg.org>
- 14 Spinal Cord Injury Quality Enhancement Research. Initiative (SCI QUERI) Washington DC: U.S. Department of Veteran Affairs; [updated 24 September 2013; cited 16 September 2012]. Available from <http://www.queri.research.va.gov/sci/default.cfm>
- 15 Scott SD, Albrecht L, O'Leary K, Ball GD, Dryden DM *et al*. A protocol for a systematic review of knowledge translation strategies in the allied health professions. *Implement Sci* 2011; **6**: 58.
- 16 Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiol Community Health* 1998; **52**: 377–384.
- 17 Samoocha D, Bruinvels DJ, Elbers NA, Anema JR, van der Beek AJ. Effectiveness of web-based interventions on patient empowerment: a systematic review and meta-analysis. *J Med Internet Res* 2010; **12**: e23.
- 18 Bloemen-Vrencken JH, de Witte LP, Engels JP, van den Heuvel WJ, Post MW. Transmural care in the rehabilitation sector: implementation experiences with a transmural care model for people with spinal cord injury. *Int J Integr Care* 2005; **5**: e02.
- 19 Bloemen-Vrencken JH, de Witte LP, Post MW, Pons C, van Asbeck FW *et al*. Comparison of two Dutch follow-up care models for spinal cord-injured patients and their impact on health problems, re-admissions and quality of care. *Clin Rehabil* 2007; **21**: 997–1006.
- 20 Browner CM, Bessire GD. Developing and implementing transdisciplinary rehabilitation competencies. *SCI Nurs* 2004; **21**: 198–205.
- 21 Burns SP, Nelson AL, Bosshart HT, Goetz LL, Harrow JJ *et al*. Implementation of clinical practice guidelines for prevention of thromboembolism in spinal cord injury. *J Spinal Cord Med* 2005; **28**: 33–42.
- 22 de Groot S, Bevers G, Post MW, Woldring FA, Mulder DG *et al*. Effect and process evaluation of implementing standardized tests to monitor patients in spinal cord injury rehabilitation. *Disabil Rehabil* 2010; **32**: 588–597.
- 23 Goetz LL, Nelson AL, Guihan M, Bosshart HT, Harrow JJ, Gerhart KD *et al*. Provider adherence to implementation of clinical practice guidelines for neurogenic bowel in adults with spinal cord injury. *J Spinal Cord Med* 2005; **28**: 394–406.
- 24 Hutchison C, Armstrong M. Development and implementation of regional guidelines for malignant spinal cord compression. *Int J Palliat Nurs* 2010; **16**: 320–326.
- 25 Pease NJ, Harris RJ, Finlay IG. Development and audit of a care pathway for the management of patients with suspected malignant spinal cord compression. *Phys Ther* 2004; **90**: 27–34.
- 26 Vitaz TW, McIlvoy L, Raque GH, Spain DA, Shields CB. Development and implementation of a clinical pathway for spinal cord injuries. *J Spinal Disord* 2001; **14**: 271–276.
- 27 Wallace CM, Legro MW. Using formative evaluation in an implementation project to increase vaccination rates in high-risk veterans: QUERI Series. *Implement Sci* 2008; **3**: 22.
- 28 Weaver FM, Smith B, LaVela S, Wallace C, Evans CT, Hammond M *et al*. Interventions to increase influenza vaccination rates in veterans with spinal cord injuries and disorders. *J Spinal Cord Med* 2007; **30**: 10–19.
- 29 Wells JD, Nicosia S. The effects of multidisciplinary team care for acute spinal cord injury patients. *J Am Paraplegia Soc* 1993; **16**: 23–29.
- 30 Guihan M, Bosshart HT, Nelson A. Lessons learned in implementing SCI clinical practice guidelines. *SCI Nurs* 2004; **21**: 136–142.
- 31 Brouwers MC, Garcia K, Makarski J, Daraz L, Evidence Expert Panel, KT for Cancer Control in Canada Project Research Team. The landscape of knowledge translation interventions in cancer control: what do we know and where to next? A review of systematic reviews. *Implement Sci* 2011; **6**: 130.
- 32 Rabin BA, Glasgow RE, Kerner JF, Klump MP, Brownson RC. Dissemination and implementation research on community-based cancer prevention: a systematic review. *Am J Prev Med* 2010; **38**: 443–456.
- 33 Thompson DS, Estabrooks CA, Scott-Findlay S, Moore K, Wallin L. Interventions aimed at increasing research use in nursing: a systematic review. *Implement Sci* 2007; **2**: 15.
- 34 Wensing M, Wollersheim H, Grol R. Organizational interventions to implement improvements in patient care: a structured review of reviews. *Implement Sci* 2006; **1**: 2.

- 1 Balas EA, Boren SA. *Yearbook of Medical Informatics: Managing Clinical Knowledge for Health Care Improvement*. Schattauer: Stuttgart, Germany, 2000.
- 2 Morris ZS, Wooding S, Grant J. The answer is 17 years, what is the question: understanding time lags in translational research. *J R Soc Med* 2011; **104**: 510–520.
- 3 Jette DU, Halbert J, Iverson C, Miceli E, Shah P. Use of standardized outcome measures in physical therapist practice: perceptions and applications. *Phys Ther* 2009; **89**: 125–135.

- 35 Scott SD, Albrecht L, O'Leary K, Ball GD, Hartling L, Hofmeyer A *et al*. Systematic review of knowledge translation strategies in the allied health professions. *Implement Sci* 2012; **7**: 70–5908-7-70.
- 36 Boaz A, Baeza J, Fraser A, European Implementation Score Collaborative Group (EIS). Effective implementation of research into practice: an overview of systematic reviews of the health literature. *BMC Res Notes* 2011; **4**: 212.
- 37 Compton S, Lang E, Richardson TM, Hess E, Green J, Meurer W *et al*. Knowledge translation consensus conference: research methods. *Acad Emerg Med* 2007; **14**: 991–995.
- 38 Wallin L. Knowledge translation and implementation research in nursing. *Int J Nurs Stud* 2009; **46**: 576–587.
- 39 Grimshaw J, Eccles M, Tetroe J. Implementing clinical guidelines: current evidence and future implications. *J Contin Educ Health Prof* 2004; **24** (Suppl 1), S31–S37.
- 40 McKibbin KA, Lokker C, Wilczynski NL, Ciliska D, Dobbins M, Davis DA *et al*. A cross-sectional study of the number and frequency of terms used to refer to knowledge translation in a body of health literature in 2006: a Tower of Babel? *Implement Sci* 2010; **5**: 16.
- 41 Spinal Cord Injury Knowledge Mobilization Network (KMN) SCI KMN; 2012 [cited 16 September 2012]. Available from <http://scikmn.com>.

Supplementary Information accompanies this paper on the Spinal Cord website (<http://www.nature.com/sc>)