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Sustainability of evidence-based acute pain management practices for hospitalized older adults

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Abstract

Little is known regarding sustainability of evidence-based practices following implementation. This paper reports sustainability of evidence-based acute pain management practices in hospitalized older adults following testing of a multifaceted Translating Research Into Practice (TRIP) implementation intervention. A cluster randomized trial with follow up period was conducted in twelve Midwest USA hospitals (6 experimental; 6 comparison). Use of evidence-based acute pain management practices and mean pain intensity were analyzed using generalized estimating equations across two time points (following implementation and 18 months later) to determine sustainability of TRIP intervention effects. Summative Index scores and six of seven practices were sustained. Experimental and comparison group differences for mean pain intensity over 72 hours following admission were sustained. Results revealed most evidence-based acute pain management practices were sustained for 18 months following implementation. Further work is needed to identify factors impacting sustainability of evidence-based practices to guide development and testing of sustainability strategies.

Keywords

sustainability; evidence-based practice; acute pain management; older adults; implementation

Addressing the final step of bringing research findings into mainstream practice is an important challenge (Avorn & Fischer, 2010). A body of knowledge in implementation science is growing and provides an empirical base for promoting adoption of evidence-based practices (EBP; Grimshaw, Eccles, Lavis, Hill, & Squires, 2012). Much attention in

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Authors' Contributions

CS was the major contributor in writing and preparing the final manuscript. MT was principal investigator on the original study and conceived the design for the present study. KH was co-principal investigator on original study. XX was the statistician who analyzed and assisted with interpretation of the data. All authors contributed to the preparation of the final manuscript and have read and approved the final manuscript.

Conflict of Interest
None declared.

implementation science has focused on testing implementation interventions for EBP adoption; developing and testing conceptual models; understanding interactions among practice context, implementation interventions, and EBP adoption; and addressing methodological issues and instrumentation. Less attention has been given to understanding the sustainability of the practice changes following use of planned implementation interventions to align practices with the evidence-base.

Sustainability refers to the degree to which practice changes from intervention effects continue following implementation (Davies & Edwards, 2013; Moore, Mascarenhas, Bain, & Straus, 2017; Rogers, 2010; Shediac-Rizkallah & Bone, 1998). Literature on sustaining EBP changes is increasing, although more research is needed on how to mitigate the decay of EBP changes and explicate factors associated with sustaining gains achieved during implementation (Davies & Edwards, 2013). Given the considerable effort and resources required to implement EBPs, it is crucial to determine if improvements in EBPs are sustained or decay following implementation (Ilott, Gerrish, Pownall, Eltringham, & Booth, 2013; Titler, 2004).

A seminal review called for consensus on operational and conceptual definitions of sustainability (Shediac-Rizkallah & Bone, 1998); however, few published studies (< 30%) have heeded their exhortation (Stirman et al., 2012). Nearly half measured sustainability through self-reports or interviews suggesting that more comprehensive and rigorous methods are needed (Stirman et al., 2012; Glasgow & Chambers, 2012). Rigorous studies evaluating the sustainability of intervention effects are paramount to advancing knowledge in this relatively under-studied area of implementation science (Ilott et al., 2013; Proctor et al., 2015).

The effectiveness of a Translating Research Into Practice (TRIP) implementation intervention, tested through a multi-site, cluster randomized trial, resulted in improvements in acute pain management of older adults hospitalized with a hip fracture (Titler, Herr, Brooks, et al., 2009; Brooks, Titler, Ardery, & Herr, 2009). The purpose of this study is to examine the sustainability of these improvements 18 months following completion of the implementation phase.

Conceptual Framework

Developed from Rogers' Diffusion of Innovations framework (Rogers, 2010), the Translation Research Model, provided guidance for the study and was used to organize the components of the multifaceted TRIP implementation intervention (Titler, 2004; Titler & Everett, 2001; Titler, Herr, Brooks, et al., 2009). The model addresses four areas that affect adoption and sustainability of EBPs: the characteristics of the EBP clinical topic (e.g. acute pain management of older adults) and how it is communicated to users (e.g. nurses and physicians) in the social system (e.g., hospital, patient care unit). The multifaceted TRIP intervention addressed all four components (see Figure 1) and is described in detail elsewhere (Titler, Herr, Brooks, et al., 2009).

Hypotheses

The following hypotheses were set forth for this sustainability study:

Hypothesis 1—Experimental and Comparison group differences in use of evidence-based acute pain management practices for hospitalized older adults observed at the end of implementation will be sustained for 18 months.

Hypothesis 2—Experimental and Comparison group differences in the mean pain intensity of hospitalized older adults observed at the end of implementation will be sustained for 18 months.

Methods

Design

This is an 18 month follow up of a cluster randomized trial conducted at twelve Midwest hospitals in the U.S. (Titler, Herr, Brooks, et al., 2009). The TRIP intervention was tested using twelve adult, noncritical care units that cared for the majority of hip fracture patients admitted to the hospital.

For this follow-up study, data were collected for 18 months after completion of implementation (T3) and compared to data immediately following implementation (T2) (see electronic supplemental material, Figure 2). Sustainability was tested by examining experimental (E) and comparison (C) group differences in nurse and physician evidence-based acute pain management practices (H1) and mean pain intensity (H2) at the 18 month follow-up (T3) with differences at the end of implementation (T2). Sustainability was defined as non-significant interaction effects of time (T3 vs T2) by treatment group (E vs C) for the process and outcome variables. The study was approved by the Human Subjects Review Board at the investigators' institution and at the participating hospitals.

Setting and Randomization

Each of the twelve hospitals discharged per year at least 30 patients ≥ 65 years of age who were hospitalized for a hip fracture. Hospitals were stratified by size (small, medium, large) and then randomized to an experimental (E) or comparison (C) group. Each arm was comprised of six hospitals: two small hospitals (<300 beds), three medium hospitals (300–500 beds), and one large hospital (>500 beds). Each hospital identified the non-intensive care unit admitting the most hip-fracture patients to be included in the study. The six E units received the TRIP intervention and the six C units received the EBP guidelines for acute pain management of older adults (Titler, Herr, Brooks, et al., 2009).

Sample

The sample consisted of up to 75 medical records per study unit of randomly selected medical records of patients meeting the following inclusion criteria: age ≥ 65 years; primary diagnosis of hip fracture; admitted to a study unit; and not transferred to an intensive care unit for the first 72 hours following hospital admission. A total of 3,548 medical records of patients met the eligibility criteria (T2= 1,388; T3= 2,160) and served as the pool for random

selection. Sample size was estimated a priori based on a power of .80, an alpha of .05, and an intraclass correlation of .5 (Titler, Herr, Brooks, et al., 2009).

Study Intervention

Promoting and sustaining adoption of EBPs is not necessarily a linear process, but rather a dynamic process of adapting to the local need and practice context (Chambers, Glasgow, & Stange, 2013). Few studies have addressed the determinants of sustaining EBPs following adoption (Eccles et al., 2009). Higuchi, Davies, Edwards, Ploeg, and Virani (2011) recommend that implementation interventions be designed with a focus on sustaining or continually improving the core clinical processes and outcomes of interest. Addressing sustainability during development and delivery of implementation interventions may significantly contribute to sustaining EBP delivery and improvements in patient outcomes (Ploeg et al., 2014; Scheirer, 2013; Scheirer & Dearing, 2011).

As such, the multi-faceted TRIP intervention included implementation strategies that addressed both adoption and sustainability of EBPs (see Figure 1). Implementation strategies designed to promote adoption of EBPs are described elsewhere (Titler, Herr, Brooks, et al., 2009). To address sustainability, we included the following implementation strategies in the TRIP intervention: 1) incorporating EBPs into organizational standards of care (e.g. policies, procedures); 2) dissemination of training materials for use with orientation of new staff; 3) provision and use of standardized pain assessment tools; 4) assisting with revisions in policies, procedures, standards, and documentation systems; and 5) assisting with revisions and/or development of standardized order sets for older adults with hip fracture. In addition, following completion of the implementation phase, we had a summation meeting with the experimental sites to 1) provide our preliminary findings, and 2) provide a discussion and recommendations about further improvement and sustaining the gains achieved.

Dependent Variables and Study Instruments

The following physicians' and nurses' evidence-based acute pain management practices for hospitalized older adults were the dependent variables for H1: every 4-hour pain assessment; pain reassessment 60 minutes following analgesic administration; avoiding prescription and administration of meperidine; prescription of patient-controlled analgesia (PCA); prescription and administration of around-the-clock opioid and non-opioid analgesics; parenteral morphine equivalent of opioids ordered and administered; and therapeutic acetaminophen dosing. In addition, overall adoption was examined using the Summative Index of Quality of Care for Acute Pain Management in Older Adults, described below (Titler, Herr, Xie, et al., 2009).

A 19-page medical record abstract form (MRAF) was used to collect data and examine nurse and physician acute pain management practices (dependent variables listed above). The MRAF is similar to those used in observational studies on adherence and recommended by pain experts (Buchanan, Voigtman, & Mills, 1997; Carr & Jacox, 1997). Interrater reliability ($r = .92 - .95$) and intrarater reliability (.92–1.0) have been demonstrated (Titler, Herr, Brooks, et al., 2009).

The Summative Index is a quantitative measure of EB acute pain management practices reflective of multiple key indicators (an index across practice behaviors) using data from the MRAF (Titler, Herr, Xie, et al., 2009). It provides an overall score (0–18) that reflects the evidence-based acute pain management interventions received by the patient (Titler, Herr, Xie, et al., 2009). Higher values reflect receipt of more evidence-based acute pain care. Validity and reliability of the Summative Index were established through factor analysis, discriminate validity, and split-half reliability (Titler, Herr, Xie, et al., 2009).

Mean pain intensity (0= no pain to 10= worst pain) over the first 24 hours and over the first 72 hours after admission to the patient care unit were the dependent variables for H2. Data from the MRAF were used to calculate these measures by summing the pain intensity scores across the time frame (24 or 72 hours) and dividing by the number of assessments (Titler, Herr, Brooks, et al., 2009).

Data Collection Procedures

Data from medical records of eligible patients were collected retrospectively by a trained research assistant (RA) using the MRAF and detailed instruction manual. Medical records personnel from each site submitted a list of all eligible patients admitted to the study units during the sustainability phase. Following random selection, medical records were accessed on site by the trained RA, inclusion criteria were validated and data were abstracted for the first 72 hours following patient admission to the unit.

Data Management

Data from the medical record abstract forms were double entered by a data entry service. Frequencies, means, ranges, and other basic statistics were generated to check for out-of-range values and missing data. Data were corrected and revisions reviewed by three research staff for accuracy.

Statistical Analyses

Data were analyzed using the Statistical Analysis System software (SAS 9.0). Descriptive statistics were run for all variables by intervention group and time period.

Generalized estimating equations (GEE) were used to analyze sustainability because this approach supports modeling a variety of longitudinal and correlated data (Diggle, Heagerty, Liang, & Zeger, 2002; Donner, 1985; Liang & Zeger, 1986). Medical records of patients were the unit of analysis while accounting for the correlation among patients treated at the same hospital. A two-tailed 5% significant level was adopted for all tests.

To examine sustainability primary and explanatory GEE models were estimated, focusing on the *interaction term* of time (T3 vs. T2) by treatment group (E vs. C). If a significant intervention effect at T2 was observed ($p < .05$), a non-significant ($p > .05$) interaction term (time by treatment group) at T3 was defined as sustainability. Following primary analyses, explanatory statistical models including other variables beyond the investigators' control that may impact primary findings were examined (e.g., case mix index; registered nurse skill

mix). Non-inferiority tests were not used because recommended tolerance margins were not available in the literature.

Results

Demographic Characteristics of Patient Medical Records

Following random selection, the final sample consisted of 1,727 medical records of patients (T2= 669; T3= 1,058) whose mean age was greater than 80 years [T2: E= 83.9 (8.5), C= 84.3 (8.1); T3: E= 83.7 (7.8), C= 84.5 (8.4)]. The sample was predominantly white and female (see Table 1). Demographic characteristics did not differ significantly by treatment group or time point.

Hypothesis 1: Sustainability of Improvements in Nurse and Physician Practices

Based on primary analytic models (see Table 2), practices significant at T2 ($p < .05$) were sustained ($p > .05$) at follow-up (T3) for: 1) around-the-clock opioid administration over 72 hours; 2) around-the-clock non-opioid administration during the third 24 hours after admission; 3) avoiding meperidine administration; and 4) around-the-clock opioid orders. Every 4-hour pain assessment, found significant at T2, decreased at T3 (Table 2) indicating the differences between the E and C groups were not sustained following the implementation phase.

Based upon explanatory analyses (see Table 3), practices that were significantly different between E and C groups at T2 and were sustained at follow-up (T3) are 1) pain reassessment; 2) around-the-clock opioid administration during the first 24 hour period after admission; 3) therapeutic dosing of acetaminophen during the third 24 hour period after admission; 4) PCA orders; 5) avoiding meperidine orders; and 6) around-the-clock non-opioid orders. The Summative Index, reflecting the amount of evidence-based care received by patients, was also sustained. As found in primary analyses, differences between E and C groups for every 4-hour pain assessment declined significantly from T2 to T3 in the explanatory models. Closer examination of the data revealed improvement in every 4-hour pain assessment in the C group from T2 (9.4%) to T3 (22.3%) while the E group remained relatively consistent from T2 (26.3%) to T3 (28.6%).

Covariates that were significant in the explanatory sustainability models (Table 3) are summarized in Table 4. Sustainability of two dependent measures – the Summative Index and therapeutic dosing of acetaminophen during the last 24 hours of care - were associated with the most covariates (Table 4). Covariates associated with sustainability across the dependent measures were patient age, being a male, and no history of dementia.

Hypothesis 2: Sustainability for Improvements in Mean Pain Intensity

Primary models were not significant for sustainability of mean pain intensity over the first 24 hours or over the first 72 hours following admission. Explanatory models demonstrated sustained differences in E and C groups for mean pain intensity over 72 hours following admission (Table 5). E group mean pain intensity over 72 hours was 3.2 (0–10 scale) and 2.9 at T2 and T3, respectively. For the C group, mean pain intensity over 72 hours was 3.3 at T2

and 3.1 at T3. Older age and being of male gender were associated with sustainability for lower mean pain intensity over 72 hours. Differences in E and C groups were not sustained for mean pain intensity over 24 hours (Table 6). Closer examination of the data revealed the E group mean pain intensity over the first 24 hours was 3.9 at T2 and T3 while mean pain intensity for the C group was 4.4 at T2 and improved to 3.7 at T3.

Discussion

In this study, most differences between E and C groups regarding use of evidence-based acute pain management practices for older hospitalized adults were sustained for 18 months. Differences between E and C groups regarding the amount of evidence-based acute pain management received by patients as measured by the Summative Index were also sustained. The TRIP intervention deliberately integrated implementation strategies designed to encourage sustainability in evidence-based acute pain management practices (Titler, Herr, Brooks, et al., 2009). These implementation strategies may have contributed to the sustainability of practice improvements by equipping clinicians with tools and resources for their ongoing use. Our findings support the growing recognition of the need for addressing sustainability in the development and selection of implementation interventions (Chambers et al., 2013; Proctor et al., 2015; Stacey, Pomey, O'Connor, & Graham, 2006; Stirman et al., 2012), and contribute to the growing literature on sustainability of patient-level benefits following successful implementation of EBPs (Tricco et al., 2016).

Differences between E and C groups for dependent variables of pain assessment every 4 hours and mean pain intensity over 24 hours were not sustained at 18 months. During the sustainability period, new standards for pain assessment and management were introduced by regulatory and accreditation organizations (Phillips, 2000), which may explain improvements in the C group resulting in less differences between groups. This finding provides additional support for considering in future research the effect of dynamic context factors on sustainability (Chambers et al., 2013).

This study had several limitations. Since there is no well-accepted definition of sustainability, we chose to use a less rigorous but easy to understand definition, rather than a formal statistical non-inferiority test. A formal non-inferiority test requires a well-accepted margin of tolerance which is not determined. Second, since the TRIP intervention was multifaceted, the individual effect of each implementation strategy on the sustainability is unclear. However, implementation strategies in the TRIP intervention designed to address sustainability were reported as highly helpful (see electronic supplemental material Table 7). Although we used selected organization and unit practice context factors as confounding variables (e.g., nurse skill mix, case mix index, hospital size), our study did not fully address other context factors on sustainability such as nursing leadership. The effects of context factors (e.g., unit climate, leadership behaviors for EBP) on sustainability would be important to examine in future research (Proctor et al., 2015, Shuman, Ploutz-Snyder, & Titler, 2017). Despite these limitations, this is one of few studies providing empirical evidence to the growing body of implementation science with respect to sustainability.

Results from this sustainability study have several implications. First, the TRIP implementation intervention demonstrated effective sustainability in use of EBPs for 18 months following implementation. The TRIP intervention included numerous, deliberate strategies intended to assist in successful implementation while contributing to overall sustainability. However, the mechanisms by which these strategies contribute to sustainability need further investigation. In addition, future implementation research should include a sustainability phase to contribute to the gaps in the science. Studies are also needed to test sustainability interventions – that is interventions at strategic times following implementation to prevent decay or drift in the evidence-based processes of care. Future research should also address the cost-effectiveness of sustainability intervention. In summary, the TRIP implementation intervention was effective in promoting sustained improvements in acute pain management practices for hospitalized older adults.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Translation Research Model.
Implementation strategies comprising the Translating Research into Practice (TRIP) implementation intervention.
Implementation strategies designed to sustain EBPs.

Table 1

Sample Demographics (N=1,727) (by time and group).

	Time 2		Time 3	
	Post Implementation		18-month Follow-up	
	Experimental (N=338)	Comparison (N=331)	Experimental (N=531)	Comparison (N=527)
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
Race White	323 (95.4)	323 (97.5)	508 (95.7)	509 (96.0)
Gender Female	255 (75.2)	261 (78.8)	395 (74.5)	408 (77.4)
<i>Chronic Disease Histories:</i>				
Dementia	82 (24.2)	90 (27.3)	131 (24.7)	171 (32.5)
Atherosclerosis	88 (26.0)	69 (21.0)	140 (26.4)	70 (13.3)
Heart Failure	58 (17.2)	46 (14.0)	77 (14.5)	86 (16.3)

Table 2

Primary Analyses: Sustainability of Treatment Effects Between Experimental and Comparison Groups from T2 to T3.

Measures	MODEL 1			MODEL 2		
	Differences Between E and C Groups at T2			Time (T2 to T3) by Treatment Group Interaction		
	Expected Direction ^a	β_{main}	p-value	$\beta_{interaction}$		p-value
Nurse evidence-based practices for pain management						
Every 4 hour pain assessment	↑	0.990	.05	−0.998		<.01
<i>A-t-C opioid administration – over 72 hours</i>	↑	0.955	<.01	0.055		.93
<i>A-t-C administration of nonopioids–third 24 hours</i>	↑	0.539	.03	0.018		.96
<i>Meperidine administration</i>	↓	−0.593	.01	−0.153		.73
Physician evidence-based practices for pain management						
<i>A-t-C opioid orders</i>	↑	0.854	.04	0.253		.73

^a Coefficient movement expected with effective TRIP implementation. ↑, increase; ↓, decrease; A-t-C, around-the-clock. Variables with significant differences at T2 that were sustained at T3 are in italics.

Table 3

Explanatory Analysis: Sustainability of Treatment Effects Between Experimental and Comparison Groups from T2 to T3.

	Model 1		Model 2		
	Differences Between E and C Groups at T2		Time (T2 to T3) by Treatment Group Interaction		
	Expected Direction ^a	β_{main}	p-value	$\beta_{interaction}$	p-value
<i>Summative Index</i>	↑	1.308	<.01	-0.793	.16
Nursing evidence-based practices for pain management					
Every 4 hour pain assessment	↑	2.017	<.01	-0.998	<.01
Reassessment <60 minutes after analgesic ^b	↑	0.132	<.01	-0.045	.27
A-t-C opioid administration – first 24 hours	↑	1.999	<.01	0.600	.12
Therapeutic dose acetaminophen – third 24 hours ^c	↑	0.622	<.01	-0.102	.71
Physician evidence-based practices for pain management					
PCA orders	↑	1.350	.05	0.270	.54
Meperidine orders	↓	-1.471	<.01	0.051	.90
A-t-C nonopioid orders	↑	0.247	.02	0.284	.40

^aCoefficient movement expected with effective TRIP implementation: ↑, increase; ↓, decrease;

^bMean percent of analgesic administrations with reassessment within 60 minutes.

^c>1,500 to <4,000 mg/24 hours.

Note: A-t-C, around-the-clock, PCA, patient-controlled analgesia; NS, not significant (p -value > .05); NA, not applicable. Variables with significant differences at T2 that were sustained at T3 are in italics.

Table 4
Summary of Significant Coefficients for Covariates in Explanatory Models for Hypothesis 1.

Variables	SI	Reassessment	A-t-C administration of opioids – 1 st 24 hours	Therapeutic dosing of acetaminophen – 3 rd 24 hours	PCA orders	Avoid Meperidine orders	A-t-C nonopioid analgesic orders
Hospital size (<300 beds)	NS	NS	NS	-1.141***	NS	NS	NS
Rural hospitals	NS	NS	NS	1.018***	NS	NS	*** -0.934
CMI	-2.020***	NS	NS	NS	-1.409***	NS	NS
Patient age	-0.036***	NS	NS	-0.029**	-0.027***	-0.023**	NS
Patient sex - male	-0.275*	-0.035***	NS	-0.351**	NS	-0.302*	NS
No history of dementia	1.144***	NS	0.474**	NS	0.797***	NS	* -0.299

Note: NS = not significant (p>.05);

* = p<.05;

** = p<.01;

*** = p<.001; A-t-C = around the clock; PCA = patient controlled analgesia; CMI = case mix index.

Table 5

Explanatory Model: Mean pain intensity over 72 hours.

Variable	Time (T2 to T3) by Treatment Group Interaction	
	$\beta_{interaction}$	<i>p</i> -value
Treatment group	−0.328	.34
Baseline score	0.729	<.01
Time: T3 vs. T2	−0.134	.44
<i>Interaction (time by treatment group)</i>	−0.071	.74
Patient age	−0.015	<.01
Patient gender (male)	−0.154	.01
Hospital size (small)	–	NS
Hospital location (rural)	–	NS
Case-mix index	0.072	.005
MD years of experience	–	NS
RN years of experience	–	NS
Nurse skill mix	–	NS
MD attitudes to guidelines	–	NS

Note: NS, not significant (*p*-value > .05); MD, medical doctor; RN, registered nurse.

Table 6

Explanatory Model: Mean pain intensity over the first 24 hours.

Variable	Time (T2 to T3) by Treatment Group Interaction	
	$\beta_{interaction}$	<i>p</i> -value
Treatment group	−0.328	.34
Baseline score	0.796	<.01
Time: T3 vs. T2	−0.580	.01
<i>Interaction (time by tx group)</i>	0.568	.03
Hospital size (small)	–	NS
Hospital location (rural)	–	NS
Case-mix index	0.890	<.01
MD years experience	–	NS
RN years experience	–	NS
Nurse skill mix	–	NS
MD attitudes to guidelines	–	NS

Note: NS, not significant (*p*-value > .05); MD, medical doctor; RN, registered nurse.