Translating Research into Practice Intervention Improves Management of Acute Pain in Older Hip Fracture Patients

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Objective. To test an interdisciplinary, multifaceted, translating research into practice (TRIP) intervention to (a) promote adoption, by physicians and nurses, of evidence-based (EB) acute pain management practices in hospitalized older adults, (b) decrease barriers to use of EB acute pain management practices, and (c) decrease pain intensity of older hospitalized adults.

Study Design. Experimental design with the hospital as the unit of randomization.

Study Setting. Twelve acute care hospitals in the Midwest.

Data Sources. (a) Medical records (MRs) of patients ≥ 65 years or older with a hip fracture admitted before and following implementation of the TRIP intervention and (b) physicians and nurses who care for those patients.

Data Collection. Data were abstracted from MRs and questions distributed to nurses and physicians.

Principal Findings. The Summative Index for Quality of Acute Pain Care (0–18 scale) was significantly higher for the experimental (10.1) than comparison group (8.4) at the end of the TRIP implementation phase. At the end of the TRIP implementation phase, patients in the experimental group had a lower mean pain intensity rating than those in the comparison group ($p < .0001$).

Conclusion. The TRIP intervention improved quality of acute pain management of older adults hospitalized with a hip fracture.

Key Words. Translation, implementation, intervention, pain, elderly, hip fracture

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Evidence-based practice (EBP) is the conscientious and judicious use of current best evidence, in conjunction with clinical expertise and patient values, to guide health care decisions (Sackett et al. 2000). When EBPs are effectively implemented, patient outcomes improve and resource use declines (Newman et al. 2000; Titler 2008). Effects of translating research into practice (TRIP)

interventions have varying results, thereby requiring further study (Jones et al. 2004; Feldman et al. 2005; McDonald et al. 2005; Murtaugh et al. 2005; Fihn 2006; Kochevar and Yano 2006; Wensing, Wollersheim, and Grol 2006). The study reported here expands the knowledge about translation by testing a multifaceted TRIP intervention to improve acute pain management practices for older adults hospitalized with a hip fracture.

Several factors stimulated our interest in undertaking this study. First, there is a wealth of research evidence on acute pain management, but elders do not receive adequate pain management during hospitalization (APS 2003; Morrison et al. 2003a; Titler et al. 2003). Second, fractured hips account for over 225,000 hospitalizations annually for Medicare recipients ≥ 65 years and are projected to double by the year 2040 (Hall and Owings 2002). This is a significant population of older adults likely to have pain. Third, managing acute pain in elders with hip fracture contributes to earlier ambulation and less adverse outcomes (Morrison et al. 2003b; Herrick et al. 2004). Under assessment and treatment of acute pain in older adults is troublesome given that research demonstrates better patient outcomes and reduced resource use with optimal pain management.

Results of a multisite, randomized experimental trial to test the effectiveness of a multifaceted TRIP intervention designed to promote adoption of evidence-based (EB) acute pain management practices for older patients hospitalized with a hip fracture are reported here. Specifically, we hypothesized

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that following implementation of the TRIP intervention, (1) nurse's and physician's adoption of EB acute pain management practices for older adults will be greater in the experimental (E) versus the comparison (C) group, (2) nurse and physician barriers to use of EB acute pain management practices in older adults would be lower in the E versus C group, and (3) mean pain intensity of patients will be lower in the E versus C group. The cost analysis of the TRIP intervention (a fourth study aim) is reported elsewhere (Brooks et al. in press).

METHODS

Conceptual Framework

A translation research model (Titler and Everett 2001), developed from Rogers' (2003) diffusion of innovations (DoIs) model, provided the guiding framework for this study (see Figure 1). According to this model, adoption of an innovation is influenced by the nature of the innovation and the manner in which it is communicated to users in a social system.

An innovation is defined by Rogers (2003) as an idea, practice, or object that is new to an individual or group and is not yet used. EBPs that are not yet adopted are defined by investigators as an innovation (Farquhar, Stryer, and Slutsky 2002; Jones et al. 2004; Sales et al. 2006). EBPs detailed in the *Acute Pain Management in the Elderly Guideline* (Herr et al. 2000) served as the innovation for this study.

The TRIP intervention was based on the translation research model and addressed the characteristics of the innovation (EB acute pain management practices for older adults), the users of the EBPs, the social system (context of care delivery), and the communication strategies (Titler and Everett 2001). Thus, the multifaceted strategies for promoting use of the EBPs (the TRIP intervention) were organized by the conceptual framework illustrated in Figure 1 (characteristics of the innovation, communication process, users, and social system) and informed by prior research. The specific components of the TRIP intervention are bulleted and italicized in Figure 1 and described further under "Study Intervention."

Study Design

A randomized design was employed. Twelve Midwest acute care hospitals that discharged at least 30 patients ≥ 65 years of age per year with a hip fracture were stratified for size and randomized to an E or C group. Both groups received an EBP guideline on *Acute Pain Management in the Elderly* (Herr

Figure 1: Conceptual Model with Components of Translating Research into Practice (TRIP) Intervention Italicized

Table 1: Organizational and Unit Characteristics

<i>Organizations</i>	<i>Experimental N = 6</i>	<i>Comparison N = 6</i>
Bed capacity		
Small (<300 beds)	2	2
Medium (300–500 beds)	3	3
Large (>500 beds)	1	1
Type		
Rural	2	2
Urban	4	4
HCFA CMI ($\bar{x}$; <i>SD</i>)	1.6 (0.5)	1.5 (0.2)
Nursing skill mix ($\bar{x}$; <i>SD</i>) (% R.N. to other)	63.6 (7.4)	67.7 (3.1)
<i>Study Units</i>	<i>Experimental N = 6</i>	<i>Comparison N = 6</i>
Type		
Orthopedics	4	3
Adult Med/Surg	2	3
Average daily census ($\bar{x}$; <i>SD</i>)	24.7 (5.5)	22.1 (7.0)
Ratio of RNs to non-RNs	1.04 (0.2)	2.02 (2.0)

et al. 2000). Hospitals identified the principal non-ICU units where adult hip fracture patients were admitted, and the TRIP intervention was implemented on study units at the six hospitals in the E group. Characteristics of the hospitals and study units are in Table 1.

Practice patterns of nurses and physicians regarding acute pain management for older adults admitted with hip fracture were analyzed before and after completion of the implementation phase of the TRIP intervention. The phases of the study, intervention strategies, and corresponding measures are overviewed in Table 2.

Dependent Variables and Data Sources

Dependent variables were (a) adoption of EB acute pain management practices for older adults, (b) nurse and physician perceived barriers to EB pain management practices, and (c) mean pain intensity. Adoption of EBP was defined as (1) nurse and physician adherence to the EBP guideline as measured by acute pain management indicators abstracted from medical records (MRs), (2) nurses' perceived use of research findings to guide nursing practices for acute pain management (questionnaire), and (3) nurses' and physicians' stage of adoption of specific pain assessment and treatment practices (questionnaire). Although the hospital was the unit of randomization, the individual (patient MR/nurse/physician) was the unit of analysis. Data were collected

Table 2: Overview of Study Phases and Measures

<i>Study Phases (Time Frame)</i>	<i>Study Measures/Time</i>
Study start-up	A. Physician and nurse questionnaires
Recruitment and enrollment of sites (October 1999–January 2000)	January 2000 (before randomization)
Randomization of sites (March 2000)	January 2001 (before TRIP implementation phase)
EBP guideline developed (December 1999–July 2000)	January 2002 (near end of TRIP implementation phase)
TRIP intervention phases	B. Medical record abstract data*
I. Engagement phase	Baseline (January–December 2000)
Focus groups (July–August 2000)	Completion of TRIP implementation phase (April 2001–March 31, 2002)
Education program for senior leaders (September 2000)	C. Summative focus groups (April 2002)
Selection of opinion leaders (OLs) and change champions (CCs) (September/October 2000)	
Train-the-trainer program (October 2000)	
Feedback of performance gap assessment data (November–December 2000)	
II. Implementation phase	
Pain rating scales and QRGs distributed (January 2001)	
Web course live (January 2001)	
OLs and CCs facilitate EBP changes (January 2001–March 2002)	
APN outreach (March 2001–March 2002)	
Audit/feedback data (April 2001–March 2002)	
Monthly teleconferences (February 2001– March 2002)	
Modification of standards and documentation forms (April–December 2001)	
Articles for internal newsletters (May 2001– January 2002)	
III. Completion of TRIP implementation phase (April 2002)	

*Reflects care delivered during specified timeframe.

EBP, evidence-based practice; TRIP, translating research into practice; QRGs, quick reference guides.

before and after completion of the TRIP intervention implementation phase (see Table 2).

Sample

The sample was the MRs of patients ≥ 65 years old hospitalized with a hip fracture, and nurses and physicians who cared for these patients. MR inclusion

criteria were age ≥ 65 , 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. Nurse inclusion criteria were registered nurse, employed by the study hospital, and working at least 50 percent on the study unit. Physician inclusion criteria were M.D. or D.O. caring for patients on the study unit. The study was approved by the Internal Human Subjects Review Board at the PI's institution and corresponding human subjects review boards at participating hospitals.

Study Intervention

The translation research model guided the design of the TRIP intervention to address the characteristics of the innovation (EB acute pain management practices), communication, users, and social context (Titler and Everett 2001). Strategies for each area, outlined in Figure 1, are described below.

Characteristics of the Innovation/EBP Topic. Characteristics of an innovation affecting adoption include the relative advantage of the innovation (e.g., effectiveness, relevance to the task, social prestige); compatibility with values, norms, work, and perceived needs of users; and complexity of the innovation (Rogers 2003). EBP topics perceived as relatively simple (e.g., influenza vaccines) are more easily adopted in less time than those that are more complex (acute pain management). Strategies to promote adoption of EBPs related to characteristics of the topic include practitioner's review and "reinvention" of the EBP guideline to fit the local context, use of quick reference guides (QRGs) and decision aids, and use of clinical reminders (Balas et al. 2004; Bootsmiller et al. 2004; Bradley et al. 2004; Fung et al. 2004; Guihan, Bosshart, and Nelson 2004; Loeb et al. 2004; Wensing et al. 2006).

This component of the TRIP intervention included QRGs developed by the research team and reviewed by four national pain experts. Six QRGs addressed pain assessment, including standardized pain rating scales, principles of pain treatment, pharmacological treatment recommendations, equianalgesic chart, nonpharmacological treatment, and patient and family education related to pain management. Intervention focus groups ($N=18$) with nurses, physicians, and senior leaders were used to introduce the acute pain guideline; discuss perceptions regarding the importance, value, and benefits of acute pain management of hospitalized elders; and elicit feedback regarding the QRGs. Each E site then received multiple copies of the guideline, laminated pain rating scales for each patient room, and the QRGs to keep desired pain management practices visible.

Communication. Opinion leaders, change champions, and educational outreach along with education of practitioners are communication strategies to promote use of EBPs (Rogers 2003). Opinion leaders are a respected source of influence, trusted to judge the fit between the new practice and the local situation, alter group norms, and possess a wide sphere of influence across the practice setting (Collins, Hawks, and Davis 2000; Locock et al. 2001; Harvey et al. 2002; Greenhalgh et al. 2005; Ozer et al. 2005).

Change champions are expert practitioners within the local setting (e.g., patient care unit), committed to improving quality of care, and possessing a positive working relationship with others (Harvey et al. 2002; Rogers 2003). Because interpersonal communication with colleagues is preferred rather than Internet or traditional sources of practice knowledge (Estabrooks et al. 2003b, 2005b), “change champions” are needed for each patient care area where change is implemented.

Educational outreach promotes positive changes in practice behaviors (Horbar et al. 2004; Loeb et al. 2004; Greenhalgh et al. 2005; Murtaugh et al. 2005). It is done by a topic expert knowledgeable of the research-base (e.g., acute pain management) meeting with practitioners to inform them of the EBPs, explain the research base, and respond convincingly to challenges and debates.

Strategies of the TRIP intervention to address communication were (a) use of local physician and nurse opinion leaders, (b) use of nurse change champions, (c) outreach visits every 3 weeks ($N = 13$ visits) by an advanced practice nurse with pain management expertise to consult with the nurses and physicians on acute pain management practices, (d) education of nurse opinion leaders and change champions via a 3-day train-the-trainer program, (e) education of physician opinion leaders by the PI/Co-PI via a 60-minute educational discussion at their respective clinic using principles of academic detailing, (f) education of nursing and medical staff via a web-based course, and (g) provision of resource texts, videotapes, and training manuals. Nurse and physician opinion leaders led organization and unit-level system changes to support use of EB acute pain management practices (e.g., documentation forms, preprinted orders), led education of their peer group, altered group practice norms, and influenced their peers through point of care coaching. The nurse change champions and physician opinion leaders circulated EB facts on acute pain management of older adults, and encouraged their colleagues to align their pain practices with the evidence. Education strategies were based on studies that education alone does little to change practice behavior (Dalton et al. 1996; Cutler and Davis 2005), and that interactive and didactic education are more effective when used with other practice-reinforcing strategies (Nieva et al. 2005).

Social System. The social system (context) has a high degree of influence on adoption of an innovation (Fraser 2004a,b; Alexander et al. 2006). Leadership support is expressed through verbal/written messages, and provision of necessary resources, materials, and time to fulfill assigned responsibilities (Bradley et al. 2004; Greenhalgh et al. 2005; Centre for Health Services Research 2006). The TRIP intervention included a 60-minute continuing education program for senior administrative leaders to discuss their role in promoting adoption of EB pain management practices and foster support for revision of institution-specific documents (e.g., documentation forms, policies, and procedures). Twice during implementation, chief nurse executives were provided brief articles about the project, written specifically for each hospital, to include in organizational publications.

Users of the EB Acute Pain Management Practice. Members of a social system influence adoption of EBPs (Rogers 2003; Greenhalgh et al. 2005). Audit and feedback (A/F), performance gap assessment (PGA), and trying the EBP have been tested. PGA and A/F have consistently shown a positive effect on changing practice behavior of providers (Bradley et al. 2004; Horbar et al. 2004; Hysong, Best, and Pugh 2006; Jamtvedt et al. 2006). Early in the TRIP intervention (engagement phase), study investigators met with physician and nurses at each experimental site to review baseline performance indicators of acute pain management (e.g., avoid meperidine prescription) for patients admitted to their setting with a hip fracture (PGA). Subsequent to provision of these data, A/F of pain data were achieved through concurrent MR abstraction of older patients admitted during the implementation phase and presentation of data to nurses and physicians every 6 weeks for 10 months (six reports). A second TRIP strategy was monthly group teleconferences ($N=11$) among nurses working on the project from E sites to discuss issues, strategies for overcoming perceived barriers, progress made in education of staff, and revision of policies and documentation forms. Additionally, a computer was provided for each patient care unit, connected to the Internet, with directions for accessing an acute pain management website developed by the research team. The intervention concluded with a meeting of nurse opinion leaders, change champions, and managers from all the E sites.

Study Instruments

Study instruments consisted of a medical record abstract form (MRAF) and a questionnaire administered to nurses and physicians.

MRAF. Using recommendations for measuring conformance to a guideline (Schoenbaum et al. 1995a), a 19-page MR abstract instrument was used to determine nurse and physician acute pain management practices. Created by investigators with content expertise in acute pain management, the MRAF is similar to those used in observational studies on adherence to the AHCPR acute pain guideline (APS 1995; Rischer and Childress 1996; Buchanan, Voigtman, and Mills 1997) and recommended by pain experts (Ferrell, Whedon, and Rollins 1995).

Study variables and data elements to operationalize each were determined and used in initial development of the form. Content validity was achieved through review by three investigators with expertise in acute pain. The tool was pilot tested by abstracting 10 MRs of elderly hip fracture patients from a local health care facility resulting in minor modifications. Interrater reliability ($r = .92-.95$) was demonstrated through abstraction of 10 records by two individuals trained in use of the instrument. Intrarater reliability was demonstrated by the trained research assistant reabstracting 25 of the same records 6 months following initial abstraction. Intraclass coefficients (for continuous variables) and κ /tetrachoric values (for categorical data) (Cohen 1960; Bartko 1966; Deyo, Diehr, and Patrick 1991; Seigel, Padgor, and Remaley 1992; Hutchinson 1993) ranged from .92 to 1.0.

Dependent variables measured with the MRAF were recommended EBPs for older adults (Herr et al. 2000) including: every 4-hour pain assessment, reassessment of pain within 60 minutes following administration of analgesics, mean pain intensity, avoiding prescription and administration of meperidine, prescription of patient-controlled analgesia, avoiding prescription and administration of analgesics via the intramuscular route, prescription and administration of around-the-clock opioid and nonopioid analgesics, the parenteral morphine equivalent (PME) of opioids ordered and administered, and administration of therapeutic doses of acetaminophen.

The MRAF was also the source of data for mean pain intensity as documented on a 0 (no pain) to 10 (worst pain) scale and the Summative Index (SI) of Quality Care for Acute Pain Management. The SI was designed to enfold key indicators of EB pain management into a single score that would reflect level of overall adoption of the Acute Pain Management in the Elderly guideline. Using a Delphi approach among study investigators and four pain experts, 18 variables were selected for inclusion in the index, each representing an aspect of EB pain management care that patients might receive. For each variable, the patient received a score of 1 if the patient received the specified care and 0 otherwise. Values on individual indicators were then summed to

yield the patient's SI score (possible range 0–18). Construct validity and reliability of the SI are reported elsewhere (Titler in press).

Nurse and Physician Questionnaires. Nurse and physician questionnaires included a demographics section and two major tools. The Perceived Stage of Adoption Instrument measures nurses' and physicians' adoption of practices that have a research base (Brett 1987; Rodgers 1994; Rutledge et al. 1996; Shively et al. 1997). Each specific practice is six questions and is scored on a 0 (low adoption) to 4 (implementation) scale. Internal consistency is .95–.75, with test–retest reliability of $r = .83$ (Brett 1987; Rodgers 1994; Rutledge et al. 1996; Shively et al. 1997). For this study, the questionnaire included four sections focusing on the practices of Pain Assessment in the Elderly, Pain Assessment in the Confused Elderly, Prescription/Administration of Analgesics Around-the-Clock, and Avoiding Prescription/Administration of Demerol in Pain Treatment of Elders.

The Barriers to Optimal Pain Management tool, a modification of the Pain Management Activities Questionnaire (Dalton et al. 1995, 1996), addresses the extent that system and practice issues are perceived by nurses and physicians as barriers to pain management and includes (1) suboptimal pain assessment; (2) lack of resources such as equianalgesic conversions, clinical pharmacists, pain experts, and peer consultations; and (3) communication difficulties with patients, between nurses and physicians, and around pharmacological dose and type (see Appendix S1). Nurses and physicians rated the extent (1 = no extent; 4 = great extent) that these factors are barriers to optimal pain management. Content validity was established by review of three nurse and physician experts in acute pain and test–retest reliability resulted in $r = .83$.

The nurse questionnaire also included the Use of Research Findings in Practice Scale, a nine-point Guttman-type scale adapted from Meyer and Goes (1988) that asks respondents to select one statement that best reflects use of research-based acute pain management practices in the organization. Responses can range from 1 (“nurses are learning research findings related to acute pain management in the elderly”) to 9 (“the clinical application of research-based practices for acute pain management in the elderly is used in our unit and other units in the hospital”).

Data Collection Procedures

A list of MRs of eligible patients for each specified time period (baseline = January 1, 2000 to December 31, 2000; completion of the TRIP

implementation phase = January 4, 2001 to March 31, 2002) was provided by study sites and up to 75 MRs per site were randomly selected for each period, based on a power of .80, an α of <0.05 , and an intraclass correlation of 0.5. MRs were abstracted retrospectively at each site by a single trained research assistant.

Questionnaires were distributed to nurses and physicians at E and C sites before randomization of sites (January 2000) and annually thereafter (January 2001; January 2002). For each study unit, up to 20 randomly selected nurses meeting inclusion criteria ($N = 198$) and all the eligible physicians ($N = 89$) were invited to complete questionnaires.

Data Integrity

MR and questionnaire data were double entered by The University of Iowa 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 Analysis

MR and questionnaire data were analyzed using generalized estimating equations (GEE) (Donner 1985; Liang and Zeger 1986; Diggle et al. 2002). Primary statistical analyses compared the E and C groups, treating intrahospital correlation as a nuisance parameter (Liang and Zeger 1986; Diggle et al. 2002). An exchangeable correlation matrix ($R = CS$) was used for the intrahospital correlation structure; the GEE method is robust to this assumption (Donner 1985; Norton et al. 1996). For MR data, the effects of baseline values were incorporated into models as control variables, using a hospital's mean pre-intervention value; for physician and nurse questionnaire data, a subject's preintervention score on a variable was used as the control. Following primary analysis, we examined explanatory statistical models that included other variables beyond our control (e.g., registered nurse [RN] skill mix), but that might impact primary findings. The 5 percent level of significance was used for all the tests.

RESULTS

Study Subjects

MRs of 1,401 patients ≥ 65 years of age or older were abstracted for the first 72 hours following admission to the patient care unit. The demographic

characteristics of the pre- and postintervention E and C groups were similar. The preintervention groups ($N=379$ E; $N=353$ C) were mostly white (E = 92.1 percent; C = 98.0 percent), female (E = 78.8 percent; C = 75.1 percent), with a mean age ≥ 80 years (E = 84.0 (8.4); C = 83.8 (7.8)], and chronic disease histories of dementia (E = 29.3 percent; C = 30.6 percent), atherosclerosis (E = 25.3 percent; C = 23.0 percent), and heart failure (E = 15.6 percent; C = 15.0 percent). The postintervention groups ($N=338$ E; $N=331$ C) were mostly white (E = 95.4 percent; 97.5 percent), females (E = 75.2 percent; C = 78.8 percent), with a mean age 80 years [E = 83.9 (8.5); C = 84.3 (8.1)], and chronic disease histories of dementia (E = 24.2 percent; C = 27.2 percent), atherosclerosis (E = 26.0 percent; C = 21 percent), and heart failure (E = 17.2 percent; 14 percent).

Questionnaires were returned by 172 nurses (return rate 85–89 percent) and 61 physicians (return rate 57–66 percent). Most nurses were Caucasian (94.8 percent) females (97.1 percent), with a mean age of 39.3 years (SD = 9.1). Most had worked as an RN for over 5 years, approximately half were associate-degree prepared, and the majority worked 32 or more hours per week. Most physicians were Caucasian (94.8 percent) males (94.0 percent), with a mean age of 45.6 (SD 9.4). Most physicians were orthopedic specialists (74.5 percent) and had been in practice for 5 or more years (70.0 percent).

Hypothesis 1 Findings. We hypothesized that following implementation of the TRIP intervention, nurse's and physician's adoption of EB acute pain management practices for older adults would be greater in the E versus C group. Findings from the MR data are summarized in Table 3. The mean Summative Index score was higher in the E (mean 10.1; SD 2.9) than the C group (mean 8.4; SD 2.3), though the difference between groups was not statistically significant ($p = .1$) in the primary analysis. When other variables were included in the explanatory model, treatment group differences were significant ($p < .0001$) (Table 4). This finding indicates that, overall, patients in the E group received more EB pain practices compared with those in the C group.

The odds of patients in the E group to have pain assessed every 4 hours during their 72 hours following admission was 2.7 times greater than those in C group ($p = .05$; see Table 3). When other independent variables were added to the explanatory model (Table 4), the difference between groups was significant ($p < .0001$; OR = 7.5).

Based on primary analyses, the practice of reassessing pain within 60 minutes of administering an analgesic was not significantly higher in the E versus C group ($p = .08$; see Table 3). When other independent variables were added to

Table 3: Adoption of Individual Pain Management Behaviors at End of TRIP Implementation Phase

Measures	Expected Direction*	Primary Analyses			Explanatory Analyses		
		β	OR	<i>p</i> -value	β	OR	<i>p</i> -value
Summative Index	↑	0.8391	NA	.10	1.3080	NA	<.0001
Every 4-hour pain assessment	↑	.9897	2.7	.05	2.0176	7.5	<.0001
Reassessment <60 minutes after analgesic (mean % of analgesic administrations with reassessment within 60 minutes)	↑	.0881	NA	.08	.1324	NA	<.0001
A-t-C opioid administration—over 72 hours	↑	.9559	2.6	.0008	.5689	1.8	<.0001
A-t-C opioid administration—first 24 hours	↑	.0153	1.0	NS	1.999	7.3	<.0001
A-t-C administration of nonopioids—third 24 hours	↑	.5398	1.7	.03	.7029	2.0	<.0001
Therapeutic dose acetaminophen—third 24 hours (> 1,500 to <4,000 mg/24 hours)	↑	.3595	1.4	.06	.6223	1.9	.0002
Demerol administration	↓	-.5929	.55	.01	-.7322	.48	.0001
A-t-C opioid orders	↑	.8535	2.3	.04	.3103	1.4	.09
PCA orders	↑	.1513	1.2	NS	1.35	3.9	.05
Demerol orders	↓	-.3727	.68	NS	-1.471	.23	.007

*Movement expected with effective TRIP intervention.

↑, increase; ↓, decrease; A-t-C, around-the-clock; PCA, patient-controlled analgesia; NS, not significant (*p*-value $\geq .05$); NA, not applicable.

the explanatory model, the difference between groups was significant ($p < .0001$) (Table 4).

Based on the primary analyses, nurse's adoption of EB acute pain management practices was greater in the E than the C group for several pharmacological administrative practices (see Table 3). More patients in the E (20.7 percent) than the C group (5.7 percent) received around-the-clock administration of an opioid analgesic over the 72-hour period ($p = .0008$; odds ratio [OR] 2.6). In addition, significantly more patients in the E (41.4 percent) than the C group (28.1 percent) received around-the-clock administration of a nonopioid analgesic during the third 24-hour period after admission ($p = .03$; OR 1.7), a time when patients are likely to be transitioning from intravenous to oral analgesics. Fewer patients in the E (19.5 percent) than the C group (36.0 percent) received meperidine during the 72-hour period following admission ($p = .012$; OR 0.6). More patients in the E (44.7 percent) than the C group (38.7 percent) received therapeutic dosing

Table 4: Explanatory Models for Summative Index (SI), Every 4-Hour Pain Assessment, Reassessment within 60 minutes of an Analgesic Administration, Therapeutic Dosing of Acetaminophen during the Third 24-hour Period, and Meperidine Orders

<i>Variable</i>	<i>SI</i> β	<i>Every 4-Hour Pain Assessment</i> β	<i>Reassessment within 60 minutes</i> β	<i>Therapeutic Dosing of Acetaminophen Third 24 hours</i> β	<i>Meperidine Orders</i> β
Treatment group	1.308***	2.0176***	0.1324***	0.6223**	-1.4714**
Baseline score	1.06***	13.9732***	NS	5.8425***	4.5394***
Patient age	-0.03***	NS	NS	-0.0321***	-0.0226*
Patient gender (male)	NS	NS	-0.0443***	-0.3952*	-0.5575*
Patient ethnicity (Caucasian)	-0.9021***	NS	NS	NS	NS
Patient dementia status (no history)	1.1710***	0.9557***	NS	NS	NS
Hospital size (small)	NS	NS	0.1716***	NS	NS
Hospital location (rural)	NS	1.4301***	NS	NS	0.9652*
HCFA case-mix index	-2.7591***	NS	-0.0953**	-0.7567***	0.7707*
M.D. years since residency	NA	NA	NA	NA	-0.2548***
Physician age	NA	NA	NA	NA	NS
Nurse skill mix	0.3781***	0.6009**	NS	0.1305**	NA
R.N. years of experience	-0.7708**	1.3293***	0.10**	NS	NA
R.N. attitudes to practice guidelines	NS	NS	0.05***	NS	NA

* $p < .05$. ** $p < .01$. *** $p < .0001$.
NS, not significant; NA, not applicable.

(1,500–4,000 mg) of acetaminophen during the third 24-hour period after admission, and this difference was significant ($p = .0002$; OR 1.9) in an explanatory model (Table 4). Drug administration practices did not differ between treatment groups for the following variables: the mean PME of opioids administered and the proportion of patients who were not administered propoxyphene or an intramuscular analgesic.

Physician's adoption of EB acute pain management practices was greater in the E group for around-the-clock opioid orders (see Table 3). More patients in the E group (26.5 percent) had an order for around-the-clock administration of an opioid than those in the C group (10.5 percent) ($p = .04$; OR 2.3). When other independent variables were added to explanatory models, the differences between E and C groups were significant for not prescribing meperidine

($p = .0073$; OR = 0.6) and tended toward statistical significance for prescription of patient-controlled analgesia ($p = .05$; OR = 3.9) (see Tables 3 and 4). Physician practices did not differ significantly between treatment groups for the following variables: mean PME of opioids ordered, orders for patient-controlled analgesia, and not prescribing propoxyphene or intramuscular analgesics.

The TRIP intervention had a positive effect on nurses' self-reported adoption of EB acute pain management practices. After controlling for baseline scores, nurses in the E group had greater improvements in self-reported use of EB acute pain management practices (84 percent using EB pain management practices) than nurses in the C group (50 percent using EB pain management practices) ($p < .0001$; OR = 3.2; see Appendix S2).

Nurses in the E group also reported a more advanced stage of adoption (mean 2.8; SD 1.0) for using around-the-clock analgesics postintervention (sometimes use) than those in the C group (mean 2.2; SD 0.9; believe they should use) ($p = .006$). Scores did not differ significantly between groups for pain assessment in older adults, pain assessment of confused elders, or avoiding use of meperidine.

The TRIP intervention had less effect on physician's perceived adoption of EB acute pain management practices. A trend toward a significant treatment effect ($p = .10$) was found for avoiding prescription of meperidine; physicians in the E group reported almost always avoiding use of meperidine in older adults (mean 3.9; SD 0.4), while physicians in the C group reported sometimes avoiding meperidine (mean 3.4; SD 0.9).

Hypothesis 2 Findings. We hypothesized that the TRIP intervention would decrease nurse's and physician's barriers to using EB pain management practices. At the end of the TRIP implementation phase, nurses' total score on the barriers scale was significantly lower (better) in the E versus C group ($p = .03$). Experimental group nurses reported a significantly greater decline ($p = .04$; OR = 1.8) in the extent to which "lack of consultation with peers" was a barrier. Perceived barriers regarding "lack of pain assessment" decreased from pre to post-TRIP intervention in the E group and increased in the C group ($p = .03$; OR = 2.61).

Physicians' perceived barriers to using EB acute pain management practices did not decline significantly more from pre- to postintervention in the E versus C group for the total barriers score or for any of the items in the barriers instrument. However, there was a trend for physicians in the E group to report a greater decline in barriers regarding "lack of information on equianalgesia" ($p = .05$; OR = 1.8) and lack of "consultation with peers" ($p = .10$; OR = 1.9).

Table 5: Explanatory Models for Mean Pain Intensity over 72 Hours and during the First 24 hours

Variable	Over 72 Hours		During First 24 Hours	
	β	<i>p</i> -Value	β	<i>p</i> -Value
Treatment group	- 1.5378	<.0001	- 2.532	<.0001
Baseline score	0.5207	<.0001	0.5264	<.0001
Hospital size (small)	- 1.0179	<.0001	- 1.7347	<.0001
Patient age	- 0.0286	.0003	NS	NS
Hospital location (rural)	2.9918	<.0001	4.2862	<.0001
HCFA case-mix index	3.2358	<.0001	4.6065	<.0001
M.D. years since residency	- 0.2290	<.0001	- 0.3280	<.0001
R.N. years experience	1.7379	<.0001	NS	NS
Nurse skill mix	- 0.6185	<.0001	- 0.9676	<.0001
M.D. attitudes to guidelines	- 0.4057	<.0001	- 0.6120	<.0001

Hypothesis 3 Findings. We hypothesized that the mean pain intensity of older adults would be lower in the E versus C group following the TRIP intervention. During the first 24- and 72-hour periods following admission, mean pain intensity of the E group was 2.5 and 1.5 units (0–10 scale) lower, respectively, than the C group ($p < .0001$) (see Table 5).

DISCUSSION

Changing practice behaviors is a complex process requiring multiple strategies to address individual practitioners and the settings in which they work (Greenhalgh et al. 2005; Alexander et al. 2006; IOM Forum on the Science of Health Care Quality Improvement and Implementation 2007a, b). Study findings demonstrate that a multifaceted TRIP intervention decreases pain intensity, and positively effects clinicians' practice behaviors and barriers to use of EB acute pain management practices. These findings are consistent with other studies that demonstrate the effectiveness of multifaceted TRIP interventions (Chin et al. 2004a, b; Horbar et al. 2004; Katz et al. 2004; Lozano et al. 2004; Feldman et al. 2005; Murtaugh et al. 2005; Ozer et al. 2005; Morrison et al. 2006). This study adds to the empirical knowledge of TRIP by (1) applying the DoI framework to the clinical practice of acute pain management of older adults hospitalized with a hip fracture and (2) testing a multifaceted TRIP intervention composed of specific strategies that addressed

four areas of the DoI framework—the nature of the EBP topic, communication, users, and social system. To our knowledge, the DoI model has neither been applied to acute pain management in hospitals nor to guide selection of implementation strategies. Study findings provide recommendations for health care personnel regarding implementation interventions to improve health care practices.

The TRIP intervention demonstrated a strong effect on nurse practices but less effect on physician practices. These differences between nurse and physician practice changes may be related to possible differences in the level of engagement of nurse and physician opinion leaders, and perceived importance of acute pain management for older adults relevant to other competing clinical demands. Although not measured in this study, investigators suggest that the perceived importance of the EB is an important consideration in adoption of EBPs (Nutley and Davies 2000; Greenhalgh et al. 2005). Future research in translation science should address these important areas.

Several variables in the explanatory models were associated with EB pain management practices. For example, higher RN skill mix was positively associated with overall adoption (SI scores), other dependent measures (e.g., every 4-hour pain assessment), and inversely related to mean pain intensity suggesting that a higher RN skill mix is associated with EB pain management practices. An association between RN skill mix and quality of care has been noted by others (Kovner, Elton, and Billings 2000; Institute of Medicine 2004; Kane and Mosser 2007).

As detailed in a companion article (Brooks et al. 2008), the TRIP intervention significantly decreased cost of care per patient, while accounting for costs of the intervention. Hospitals would benefit financially from promoting EB pain management practices, as guided by the TRIP intervention, but more importantly, this vulnerable population of older adults would benefit from better management of acute pain.

Study limitations include generalizability of study findings limited to hospitalized Caucasians ≥ 65 years of age with acute pain. Additionally, the TRIP intervention was multifaceted and thus, it is unknown which strategies had the greatest effect. However, at the end of the TRIP implementation phase, nurse opinion leaders and change champions rated the usefulness of each strategy (see Appendix S3). The dose of the TRIP intervention was not measured, and this is an emerging issue in translation science discussed by others (Locock, Bucknall, and Titler 2004; Hagedorn et al. 2006; Rubenstein and Pugh 2006; Titler, Everett, and Adams 2007).

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.

Appendix S1. Items on the Barriers to Optimal Pain Management Tool.

Appendix S2. Use of Research Findings for Acute Pain Management.

Appendix S3. Perceived Helpfulness of Intervention Components.

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