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Pain Management Algorithms for Implementing Best Practices in Nursing Homes: Results of a Randomized Controlled Trial

Mary Ersek, PhD, RN,

Professor of Palliative Care, Corporal Michael J. Crescenz VA Medical Center, Philadelphia, PA, University of Pennsylvania School of Nursing, 418 Curie Blvd., Room 329, Philadelphia, PA 19104-6096, Phone: (215) 746-3563, Fax: (215) 222-2592

Moni Blazej Neradilek, MS,

The Mountain-Whisper-Light Statistics, 1827 23rd Ave. East, Seattle, WA 98112-2913, Phone: (206) 329-9325, Fax: (206) 324-5915

Keela Herr, PhD, RN, AGSF, FAAN,

Professor & Chair, Adult & Gerontology Nursing, College of Nursing, University of Iowa, 101 Nursing Building, 50 Newton Road, Iowa City, IA 52242-1121, Phone: (319) 335-7080

Anita Jablonski, PhD, RN,

Associate Professor, College of Nursing, Seattle University, 410 Garrard, Seattle, WA 98122, Phone: (206) 296-5679

Nayak Polissar, PhD, and

The Mountain-Whisper-Light Statistics, 1827 23rd Ave. East, Seattle, WA 98112-2913, Phone: (206) 329-9325, Fax: (206) 324-5915

Anna Du Pen, ARNP, MN

Retired, 14555 Wild Swan NE, Bainbridge Island, WA 98110-4102, Phone: (206) 780-8373

Mary Ersek: ersekm@nursing.upenn.edu; Moni Blazej Neradilek: moni@mwlight.com; Keela Herr: keela-herr@uiowa.edu; Anita Jablonski: jablonsk@seattleu.edu; Nayak Polissar: nayak@mwlight.com; Anna Du Pen: anna.dupen@gmail.com

Abstract

Objective—To enhance pain practices in nursing homes (NHs) using pain assessment and management algorithms and intense diffusion strategies.

Design—A cluster, randomized controlled trial. The intervention consisted of intensive training and support for the use of recommended pain assessment and management practices using algorithms (ALGs). Control facilities received pain education (EDU) only.

Setting—Twenty-seven NHs in the greater Puget Sound area participated. Facilities were diverse in terms of size, quality, and ownership.

Participants—Data were collected from 485 NH residents; 259 for the intervention and 226 for the control group.

Measurements—Resident outcomes were nursing assistant (proxy) report and self-reported resident pain intensity. Process outcomes were adherence to recommended pain practices. Outcomes were measured at baseline, completion of the intervention (ALG) or training (EDU), and again 6 months later.

Results—Among 8 comparisons of outcome measures between ALG and EDU (changes in 4 primary pain measures compared at 2 postinterventions time points) there was only 1 statistically significant but small treatment difference in proxy- or self-reported pain intensity. Resident-reported worst pain decreased by an average of 0.8 points from baseline to 6 months among the EDU group and increased by 0.2 points among the ALG ($p = 0.005$), a clinically nonsignificant difference. There were no statistically significant differences in adherence to clinical guideline practice recommendations between ALG and EDU following the intervention.

Conclusions—Future research needs to identify and test effective implementation methods for changing complex clinical practices in NHs, including those to reduce pain.

Keywords

pain; algorithm; clinical trial; nursing homes; evidence-based practice; diffusion of innovations; older adults; palliative care

Pain is common among nursing home (NH) residents^{1,2} and has significant negative effects on mood, sleep, and function.^{3–5} Despite these serious consequences, pain assessment and management for this vulnerable group is inadequate.^{1,6–8} Barriers to pain assessment and treatment in the NH are numerous and include both general difficulties in evaluating and treating pain in the older adults as well as challenges associated with the long-term care setting.^{9–12}

Several evidence-based clinical guidelines to enhance pain management for older adults, including those in NHs, have been disseminated.^{13–17} However, practice guidelines are often insufficient to change practice,¹⁸ and studies of interventions to implement pain guidelines have not demonstrated effectiveness in enhancing resident outcomes.^{19–21}

One promising approach is the embedding of guidelines into explicit protocols and algorithms to enhance decision-making. Previous clinical trials have shown that assessment and treatment algorithms are effective in improving practice and patient outcomes.^{22–25} To be maximally effective, the algorithms need to be embedded in a systematic intervention that uses effective strategies aimed at changing clinical practice. These implementation strategies include collaborative patient management, clinician education, enhanced roles for nurses, engagement of influential opinion leaders, audit and feedback, and academic detailing.²⁶

Methods

Study Purpose and Aims

The purpose of this cluster, randomized controlled trial was to enhance pain practices in NHs using pain assessment and management algorithms and intense diffusion strategies. The following study aims and hypothesis tests reported here were to:

- 1 Evaluate the effectiveness of a pain management algorithm coupled with intense diffusion strategies (ALG) as compared with pain education (EDU) only, in decreasing surrogate- and self-reported pain among NH residents at the completion of the intervention and at 6-month follow-up.

Hypothesis: At postintervention and 6-month follow-up, residents in the ALG facilities will have a greater reduction in surrogate- and self-reported pain than residents in EDU facilities.

- 2 Compare adherence to recommended pain practices between ALG and EDU facilities.

Hypothesis: At postintervention and 6-month follow-up, ALG facilities will demonstrate greater improvement on adherence to recommended pain practices compared with EDU facilities.

Design

The study used a clustered, randomized controlled trial design comparing ALG and EDU groups. The randomization scheme minimized cross-contamination between ALG and EDU facilities, which can cause dilution of the treatment effects.²⁷ Additional information about the study design and methods is available in an earlier publication.²⁸

All study procedures were reviewed and approved by the Swedish Medical Center Institutional Review Board (IRB) (FWA00000544). Every participating nursing home obtained a Federal-wide Assurance through the Office for Human Research Protections and signed written agreements to designate Swedish Medical Center as the IRB of record. Residents provided written consent or were consented by the designated healthcare proxy.

Description of Intervention and Control Conditions

Intervention—The ALG intervention consisted of intensive training and support for the use of recommended pain assessment and management practices using algorithms. The cornerstone of the intervention was the dissemination of pocket-sized handbooks containing 11 linked evidence-based decision trees for the following: general pain assessment; assessment and treatment of pain in nonverbal residents; appropriate prescribing and titration of acetaminophen, nonsteroidal anti-inflammatory drugs, opioids and adjuvant pain medications; and assessment and management of medication side effects (constipation, sedation, delirium). Licensed nursing staff each received a copy of the handbook and attended 4 classes (conducted at the facility) that covered every algorithm. Classes were videotaped for future viewing. Facilities also received 3-ring binders that contained additional resource materials to aid licensed nursing staff, administrators, primary care providers, and nursing assistants in addressing residents' pain issues.

To aid the adoption of the ALG and evidence-based pain practices, the ALG and the classes were embedded in strategies that were based on Rogers' Diffusion of Innovations Theory.²⁹ These strategies included feedback about performance, establishment of and clinical support for facility-based interdisciplinary pain teams and clinical champions, chart forms and policies to incorporate the ALG into regular practice, and 4-biweekly booster activities

begun 8 weeks following the classes. Additional information about the intervention has been described elsewhere.²⁸

Control—The control, or EDU condition, involved offering licensed nursing staff four 1-hour classes at each control facility. Classes covered basic principles of pain assessment and management for older adults. As with the ALG classes, videotapes of each session were made available to the facilities for future review by both current and newly hired nurses.

Sample

Twenty-seven NHs in the greater Puget Sound area participated. Facilities were diverse in terms of size, quality, and ownership.²⁸ Residents of participating NHs were eligible if they were age 65 years and older, identified as having moderate to severe pain, and expected to remain at the facility for at least 6 months. All residents meeting these criteria were eligible regardless of cognitive function.

Residents with pain were identified using 3 procedures. First, research staff asked unit managers (licensed nurses who oversaw resident care) to identify all residents they believed had moderate to severe pain at any time in the past week that was not adequately treated by current therapies. Second, we used the Minimum Data Set (MDS) to identify residents who had moderate to severe pain. Third, we reviewed the charts of all residents not identified as having pain using the first 2 methods for clinical notes about pain, analgesic use, or pain care plans. Residents identified in this manner were then interviewed, if possible, and screened for eligibility.

Randomization Procedures

Following collection of all baseline measures at a facility, the principal investigator (ME) contacted the statistician with the name or names of the facilities that were to be randomized along with the limited information that was necessary to monitor balance between ALG and EDU facilities. Facilities were randomized singly or in matched pairs, although the final 3 unmatched facilities were randomized simultaneously. For the first 18 facilities, pairs of facilities that were similar in size (≤110 beds or >110 beds), ownership (for profit or not for profit), and quality (based on number of deficiencies or stars on the 5-star quality rating system) were matched and randomized (1 to treatment and 1 to control with equal chance of assignment). Six of the first 18 facilities were not paired and were randomized singly with an equal chance of assignment to either condition. The last 9 facilities were randomized with an adaptive randomization that set the probability of each possible assignment according to the resulting balance in the allocation of ALG versus EDU on key facility characteristics.

Data Collection and Measures

Primary outcome: Certified nursing assistant (CNA) assessment of residents' usual pain—The primary outcome of the trial was a surrogate evaluation of residents' usual pain during the previous week. This measure was chosen to maximize statistical power because some residents were unable to self-report pain due to cognitive impairment.²⁸ Previous studies have shown that CNA reports can be highly accurate with proper training.^{30,31} Pain scores were obtained from the CNAs using a validated pain thermometer

scale where 0 = “no pain” to 12 = “the most intense pain imaginable” to be consistent with the residents’ self-report pain measure.^{32–35} To ensure that all CNAs completed the measure consistently and accurately, the investigators conducted training sessions in all participating facilities before study initiation. In addition, all facilities received an 8-minute training DVD to educate CNAs who are not able to attend the face-to-face training. Additional information about CNA training and eligibility to report residents’ pain is described elsewhere.²⁸

Secondary Outcomes: Self-reported Pain Intensity—Self-reported pain intensity was measured using the Iowa Pain Thermometer (IPT). The IPT uses a graphic representation of a thermometer in which the base is white and becomes increasingly red as one moves up. The base is anchored with the words “no pain,” and the top of the thermometer is anchored with “the most intense pain imaginable.” The IPT is reliable, valid, and generally preferred over other pain-intensity tools.^{32–35} Only data from participants who could provide verbal, reliable responses were used in the analysis for self-reported pain and have been described elsewhere.³⁶

Process outcome: Adherence to the ALG

The Pain Management Chart Audit Tool (PM-CAT) uses documentation in the medical record to evaluate adherence to the practices recommended in the evidence-based algorithms. It has 17 items; 9 items are indicators of a comprehensive, multidimensional pain assessment, and 8 indicators reflect current best pain management practices.³⁷ Scoring rules for the PM-CAT were developed by 2 nurse investigators with extensive experience in pain management and translational research. The scoring rules were pilot-tested in 2 facilities and then refined. Most indicators are scored on a scale of 0 to 2, with “1” indicating partial adherence to best practice and “2” indicating full adherence. Some items may also be scored as “N/A = Not Applicable.” Total scores are calculated as the sum of all items divided by the total possible score (which differs depending on the number of items that are N/A) $\times 100$ to yield a range of scores from 0 to 100. Three nurse coders performed all chart audits. Agreement among all PM-CAT coders was 90%. Pain assessment and management practices were evaluated for the 30-day period prior to chart review.

Descriptive Variables and Covariates

Demographic Variables—Information about the participants’ age, race, educational level, and other demographic data were abstracted from the medical record and the MDS.

Cognitive Status—Cognitive functioning was measured using the Cognitive Performance Scale, a 5-item instrument derived from the most recent MDS. Following standard decision rules, raters assign a summary score of 0 (intact) to 6 (very severe impairment).³⁸

Painful Conditions—Data about painful conditions were collected from the medical record using the MDS and the resident’s medical problem list. Two doctorally prepared gerontological nurse researchers, a gerontological nurse practitioner, and a geriatrician, each with expertise in pain management, reviewed participants’ diagnoses and judged whether each condition was consistently (ie, in at least 75% of persons with the disorder) associated with pain. At least 3 of the 4 experts had to agree for a diagnosis to be accepted as painful. A

final Painful Diagnoses score was calculated by summing all diagnoses judged as painful by the expert group. Diagnoses that appeared both in the MDS and problem list were counted only once.

MDS Pain Variables—We collected the MDS 2.0 pain frequency and intensity items, which uses nurses' proxy report of residents' pain in the previous 7 days. Frequency was scored as 0 = no pain, 1 = pain less than daily, or 2 = pain daily, and intensity was reported as missing = no pain, 1 = mild pain, 2 = moderate pain, and 3 = times when pain is horrible or excruciating. We also calculated an MDS Summary score in which the MDS pain frequency was multiplied by the MDS pain intensity, yielding a range of scores from 0 = no pain to 6 = daily pain that was at times horrible or excruciating. The MDS is required to be completed on admission, at least quarterly for long-term care residents, and following significant clinical change in resident health. We used scores from the most recent MDS that were recorded in the medical record at the time of data collection.³⁹

Depression—The Cornell Scale for Depression in Dementia (CSDD) was used to measure depression. The CSDD is a 19-item scale that includes information from semistructured interviews with participants and their caregivers. Items are grouped under categories, "mood-related signs," behavioral disturbance," "physical signs," "cyclic functions," and "ideational disturbance," and are rated 0 = absent, 1 = mild or intermittent, or 2 = severe, and then totaled to obtain a score.⁴⁰ Although originally developed for persons with dementia, the CSDD has acceptable reliability and validity in individuals who are cognitively intact as well.^{40–44}

Agitation—Agitation was measured using the valid, reliable Pittsburgh Agitation Scale (PAS).⁴⁵ The PAS is an observer rating of 4 groups of behaviors: aberrant vocalization, motor agitation, aggressiveness, and resistance to care. Overall scores range from 0–16, with higher scores denoting high levels of agitation. The PAS is significantly associated with behavioral and surrogate pain measures in NH residents with moderate to severe cognitive impairment.⁴⁶ The PAS was completed by the nurse responsible for overseeing the participant's overall plan of care.

Protocols for all screening, consenting, and data collection were developed and used to train all research assistants and investigators. Research assistants were required to achieve 85% agreement with the trainer before to collecting data. Interrater agreement was assessed at the beginning and at intervals throughout the study to verify that there was adequate agreement among research assistants. Residents and data collectors were blinded to intervention or control, with the exception of 1 team member who completed the PM-CAT at baseline in several facilities. However, blinded data collectors completed the PM-CAT at follow-up.

Statistical Methods

Residents were the primary unit of analysis for addressing the specific aims, and all analyses were based on intention to treat. Descriptive statistics are presented as percentages for categorical characteristics and as mean (SD) for continuous and ordinal characteristics. We used linear mixed models⁴⁷ to ascertain associations between outcome variables and

predictors. All linear mixed models included a random effect for the facility to account for the possible correlation of residents' outcomes within a facility. To control for baseline differences, the outcomes for the models were the changes in pain intensity and in adherence between the baseline and post-intervention time points. Linear mixed models were also used to compare continuous and ordinal resident characteristics at the baseline between the ALG and EDU groups. Logistic generalized linear mixed models were used to compare categorical resident characteristics. We carried out both unadjusted and covariate-adjusted comparisons of pain outcomes between the ALG and EDU groups. The covariate-adjusted models included factors selected into the linear mixed model with the forward stepwise variable selection technique ($P < .05$ for inclusion). The covariates considered for selection into the model were as follows: MDS pain frequency score, MDS pain intensity score, MDS summary score, the PAS score, MDS Cognitive Performance Scale, the number of painful body areas, age, gender, education, and overall CAT score. After covariates were selected, the group (ALG vs. EDU) was added into the model and the covariate-adjusted association between the binary treatment-group variable and the outcome was ascertained. Unadjusted analysis was carried out to compare adherence outcomes between the ALG and EDU groups.

Taking into account the intraclass correlation for residents within facilities, the study was powered for an effective sample size of 144 residents, which, evenly divided between 2 arms, would yield a detectable effect size of 0.5; that is, a true difference of outcome means that was at least one-half of an SD would have 80% power to yield statistical significance ($P < .05$, 2-sided test).⁴⁸ All calculations were performed in the statistical language R, version 2.13.0 (Vienna, Austria).

Results

Of the 27 participating facilities, 13 were randomized to the intervention and 14 to the education only-control. There were no statistically significant differences between the intervention and control facilities with regards to number of beds, Centers for Medicare and Medicaid star rating, number of deficiencies, or type of ownership (not for profit, for profit, government).²⁸

The final total resident sample ($N = 485$, Figure 2) consisted largely of white, non-Hispanic women in their mid-80s, which is similar to the population of NH residents in western Washington. Baseline characteristics of the 2 groups were similar with regards to demographic, clinical, and outcome variables (Table 1). The only statistically significant difference at baseline was the mean MDS pain summary score, which was a control variable in the particular multivariate analyses for which it earned entry into the multivariate model.

Comparisons between ALG and EDU on Resident Pain Outcomes

Table 2 shows the means and SD of the pain outcomes for the control and intervention groups at baseline, immediately after the intervention, and at 6 months. The mean CNA-reported usual pain improved slightly between baseline and 6 months in both groups: from 3.0 to 2.7 in the control and from 3.4 to 3.0 points in the intervention group. Similarly, small improvements were observed for the means of the other 3 pain outcomes, with the exception

of the resident-reported usual and worst pain scores in the intervention group that increased slightly (from 5.4 to 5.5 points and from 7.8 to 8.1 points, respectively).

Table 3 shows the unadjusted comparison of the pre- versus postintervention changes in pain between the control and intervention residents (Aim 1). The pre- versus postintervention changes in all 4 outcomes, both postintervention timepoints and both groups were less than 1 point. The largest observed difference in the means between the control and intervention groups occurred for the change in the resident-report of worst pain from the baseline to the 6-month postintervention, with 0.9 points higher pain in the intervention group ($P=.005$). Although statistically significant, this small change is likely not clinically meaningful.⁴⁹ All the remaining differences were small and not statistically significant.

Similar differences in mean pain scores between the control and intervention groups were found in the covariate-adjusted analysis (Table 4.) Covariates were entered into the model using the forward selection procedure. Baseline value of the pain outcome was selected as a covariate into all 8 models. MDS pain intensity, frequency, or summary scores were selected into the 2 models for CNA-reported worst pain score and the 4 models for resident-reported pain scores. The estimated adjusted differences between the control and intervention groups were all less than 1.0 point and the only statistically significant differences was (again) observed for the change in the resident-report of worst pain from the baseline to the 6-month postintervention (intervention minus control = 0.9, $P=.002$).

Comparisons between ALG and EDU on Adherence to Recommended Pain Practices

Table 5 shows the means and SDs of the adherence outcomes for the control and intervention groups at baseline, immediately after the intervention and at 6 months follow-up. The means of all 3 adherence outcomes (assessment, treatment, and total scores) improved from the baseline in both groups, although mean improvements were mostly <5%. The only exception is a 7.5% improvement in the assessment score in the intervention group between baseline and 6-months postintervention. The corresponding improvement in the control group was 2.0%; however, the difference between the control and intervention groups was not statistically significant ($P=.11$).

Discussion

In this large cluster, randomized controlled trial, a set of algorithms combined with intensive strategies to encourage adoption of evidence-based pain assessment and management practices was no better than basic education in reducing pain among older NH residents. Neither the control nor the intervention groups demonstrated clinically significant changes in pain intensity from baseline. The ALG (intervention) group did demonstrate larger increases in adherence to recommended practices over time, although these changes were modest; furthermore, there were no statistically significant differences in adherence between the ALG and EDU group over time. The trial was sufficiently powered to detect clinically significant differences in outcomes, and thus the negative results were not attributable to inadequate sample size. In an earlier publication, we described challenges in implementing the intervention, including a lack of provider/prescriber involvement and difficulties identifying precise, sensitive tools for measuring pain severity in residents with marked

cognitive impairment, that may have limited intervention effectiveness.²⁸ In this report of final outcomes, we explore below other potential reasons for our negative findings.

The lack of effectiveness in changing NH pain practice and outcomes is not unique to this trial. Using a similar, multimodal pain intervention that included staff education, Jones et al^{19,50} were unable to detect significant changes in either pain practices or residents' pain severity. In contrast, Tse et al⁵¹ tested a comprehensive 8-week pain management program that consisted of training for NH staff and delivery of intensive nondrug interventions (eg, physical exercise, multisensory stimulation therapy) for residents. They reported statistically significant differences in resident-reported pain intensity between the intervention and usual care groups, although the mean change in pain intensity for the intervention group was modest (1.7 on a 0 to 10 scale). Nevertheless, these findings suggest that targeting staff and residents alike and integrating nondrug therapies more fully into the therapeutic approaches may increase pain treatment effectiveness.

Also in contrast to our findings was the Kovach et al⁵² study, which reported that a stepped intervention to relieve discomfort in NH residents was superior to usual care. Their intervention also followed a decision tree to identify and treat discomfort, which included physical pain. The study found positive changes in analgesic administration, persistent nurse intervention to resolve discomfort, and significant decreases in observed behaviors that indicated discomfort. The success of this efficacy trial may in part be attributable to measurement of process and resident outcomes only for a select group of staff nurse interventionists who received intensive training and follow-up. Our trial was designed to test the effectiveness of an intervention under real-world conditions.⁵³ As such, our approach may have been too diffuse and weak to effect changes in outcomes.

Promoting use of evidence-based recommendations and changing provider practices has been shown to be a daunting task.⁵⁴ For this reason, the interest in implementation science has exploded since our study was designed and conducted.⁵⁵ We used a theoretical framework and evidence-based approaches for enhancing the adoption of clinical recommendations into practice, and carefully considered challenges to conducting effectiveness trials in NHs.^{28,56,57} However, we did not take complete advantage of the methods that have been recently described to study and facilitate implementation. For example, Curran and colleagues⁵³ described the value of incorporating formative evaluation during the study to identify and address barriers in real time. Although this violates the generally accepted principles of randomized controlled trial methodology, it allows investigators to tailor interventions to maximize chances of success. We did conduct focus groups at the end of the study to identify factors that facilitated adoption of the algorithm,⁵⁸ but our posthoc examination could not guide refinement of the intervention during the study. Our findings did, however, reveal barriers to implementation that have been identified in other studies, such as staff and leadership turnover, regulatory issues, lack of time, and negative staff, family, resident and provider attitudes about pain management for older adults. Facilitators to implementation included strong, supportive leadership, adoption of the Culture Change model,⁵⁹ and development and deployment of policies and procedures to guide clinical practices.⁵⁸ Future studies could incorporate early identification and tailored implementation strategies to address these barriers and facilitators to change.

Another important factor that we did not measure and adjust for is the variability among facilities in their willingness and ability to adopt practice changes. Current implementation science incorporates these key contextual variables (e.g., leadership, staff turnover, readiness for change) into newer theories, measures and methods.^{60,61}

Another factor that likely impeded our ability to change outcomes is the complexity of activities needed both to assess and manage pain, as well as to adopt these practices consistently in to clinical practice. Rogers' theory²⁹ posits that innovations that are perceived to be relatively easy to understand and use are more likely to be adopted. Although our algorithms led clinicians through a step-by-step process to assess and treat pain, they were detailed and overlapping, reflecting the complex processes needed to make clinical decisions related to pain treatment. Adoption may have been facilitated by a more modular approach in which we allowed clinicians to learn, practice, and master 1 step (eg, assessment) before moving to a new clinical skill such as initiating and monitoring opioid therapy.⁶² This mastery and adoption of a specific practice could be assessed both on the individual clinician level and on a facility level. Such a stepped approach would require incorporation of regular audit with feedback, an implementation strategy that has been more recently widely studied and validated.⁶³ We provided some feedback to pain teams about their clinical practices, but the audits were infrequent (1–3 per intervention facility) and the methods of feedback were not uniformly delivered and discussed.

Finally, one needs to acknowledge that the state of the science around pain in older adults is not ideal. Although many clinical guidelines exist for assessing and managing pain in older adults,^{13,14,16,17,64} most of the recommendations come from low to moderate levels of evidence rather than multiple, rigorous controlled clinical trials. Thus, the premise that strict adherence to the myriad of recommended practices improves pain outcomes for frail older adults is largely untested. Another challenge in conducting clinical trials aimed at improving pain assessment and management is choosing an appropriate primary outcome. Although pain intensity is commonly used as an outcome in pain trials, multidimensional pain measures may better capture clinically meaningful outcomes.

Conclusion

In this article, we report the results of a large cluster, randomized controlled trial to improve pain assessment and management practices in NHs using algorithms and selected implementation strategies. Our intervention failed to achieve clinically significant impacts on clinical practices or outcomes. Future studies must incorporate new knowledge about implementation research findings into practice and address the complex nature of assessing and treating pain in older NH residents.

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Fig. 1. Schematic of the study activities

Figure 2. CONSORT diagram of participant recruitment and retention

^aReasons: death (46), moved/hospitalized (6), dropped due to illness (4)

^bReasons: death (36), moved/hospitalized (7), dropped due to illness (2)

Table 1

Baseline characteristics of study participants

Characteristic	Algorithm Intervention (n = 259)	Control (n = 226)	P-value
Age, mean (SD) [†] years	83.9 (8.3)	84.3 (7.6)	1.0
Female, %	70%	77%	0.9
Education, %			0.7
High school or less	57%	59%	
Post-secondary education	43%	41%	
White, Non-Hispanic, %	94%	89%	0.3
Cognitive Performance Scale, mean (SD) (possible range 0–6)	2.29 (1.46)	2.71 (1.38)	0.10
MDS [*] 2.0 pain intensity score, mean (SD) (possible range: 0–3)	1.32 (1.02)	1.06 (1.06)	0.054
MDS pain summary score, mean (SD) (possible range: 0–5)	2.29 (1.67)	1.78 (1.67)	0.02
Pittsburgh Agitation Score, mean (SD) (possible range: 0–16)	1.78 (2.38)	1.99 (2.54)	0.6
Number of painful condition, mean (SD) (actual range: 0–7)	1.91 (1.46)	1.63 (1.30)	0.2

[†] SD: standard deviation^{*} MDS: Minimum Data Set

Table 2

Descriptive statistics for the pain outcomes, by treatment and visit.

EDU Control (N=226)				ALG Intervention (N=259)				
All subjects		Subjects with all three time points		All subjects		Subjects with all three time points		
N	Mean±SD	N	Mean±SD	N	Mean±SD	N	Mean±SD	
CNA [*] -reported usual pain								
Baseline	224	3.1±2.6	180	3.0±2.6	253	3.4±2.6	201	3.4±2.6
Postinterventions	197	2.7±2.5	180	2.7±2.6	231	3.1±2.6	201	3.1±2.6
6-month follow-up	182	2.7±2.4	180	2.7±2.4	203	3.0±2.7	201	3.0±2.7
CNA [*] -reported worst pain								
Baseline	170	4.5±2.9	134	4.4±2.8	212	4.9±2.8	165	4.9±2.9
Postinterventions	174	4.0±3.0	134	4.1±3.1	213	4.5±3.0	165	4.6±3.0
6-month follow-up	182	4.0±3.0	134	4.0±3.1	203	4.6±3.1	165	4.5±3.2
Resident-report usual pain								
Baseline	150	5.3±2.1	101	5.3±2.1	198	5.2±2.4	127	5.4±2.4
Postinterventions	133	4.7±2.5	101	5.0±2.4	178	5.4±2.2	127	5.8±2.0
6-month follow-up	114	4.6±2.2	101	4.7±2.2	144	5.4±2.5	127	5.5±2.4
Resident-report worst pain								
Baseline	155	7.5±2.2	107	7.6±2.2	206	7.6±2.2	136	7.8±2.1
Postinterventions	139	6.9±2.6	107	7.1±2.4	178	7.4±2.2	136	7.6±2.0
6-month follow-up	116	6.6±2.1	107	6.7±2.0	149	7.9±2.6	136	8.1±2.4

* CNA: certified nursing assistant

Table 3

Difference between ALG and EDU groups

	EDU Control		ALG Intervention		Difference (Intervention-Control)	
	<i>N</i>	<i>mean</i> ± <i>SE</i> change from baseline	<i>N</i>	<i>mean</i> ± <i>SE</i> change from baseline	<i>Diff</i> ± <i>SE</i>	<i>p</i>
CNA[*]-reported usual pain						
<i>Immediate postinterventions</i>	195	-0.3±0.2	228	-0.3±0.2	-0.1±0.3	0.8
<i>6-month follow-up</i>	180	-0.2±0.2	202	-0.4±0.2	-0.2±0.3	0.6
CNA-reported worst pain						
<i>Immediate postinterventions</i>	145	-0.3±0.3	191	-0.2±0.3	0.0±0.4	0.9
<i>6-month follow-up</i>	134	-0.4±0.4	166	-0.4±0.3	-0.1±0.4	0.9
Resident-report usual pain						
<i>Immediate postinterventions</i>	117	-0.3±0.3	165	0.2±0.2	0.5±0.3	0.11
<i>6-month follow-up</i>	108	-0.4±0.3	138	-0.0±0.3	0.4±0.5	0.4
Resident-report worst pain						
<i>Immediate postinterventions</i>	124	-0.5±0.2	172	-0.2±0.2	0.2±0.3	0.5
<i>6-month follow-up</i>	112	-0.8±0.2	147	0.2±0.2	0.9±0.3	0.005

Outcome = change from the baseline to postinterventions (either immediate postinterventions or 6-month postinterventions). Linear mixed model.

^{*} CNA: certified nursing assistant

Table 4

Multivariate models for change in pain outcomes between the baseline and postinterventions (either immediate postinterventions or 6-month follow-up).

	Immediate postinterventions		6-month Follow-up	
	<i>Coefficient±SE</i>	<i>P</i>	<i>Coefficient±SE⁺</i>	<i>P</i>
Model for CNA *-reported usual pain	<i>N=423</i>		<i>N=382</i>	
Baseline value	-0.67±0.05	<0.001	-0.72±0.05	<0.001
Intervention (vs. Control)	0.21±0.32	0.5	0.16±0.25	0.5
Model for CNA-reported worst pain	<i>N=332</i>		<i>N=296</i>	
Baseline value	-0.69±0.06	<0.001	-0.75±0.06	<0.001
MDS pain intensity			0.42±0.17	0.02
MDS summary score	0.24±0.10	0.01		
Intervention (vs. Control)	0.21±0.49	0.7	0.16±0.36	0.7
Model for Resident-report usual pain	<i>N=282</i>		<i>N=246</i>	
Baseline value	-0.72±0.06	<0.001	-0.63±0.06	<0.001
MDS pain frequency	0.41±0.18	0.03	0.51±0.20	0.01
Intervention (vs. Control)	0.39±0.27	0.2	0.49±0.32	0.14
Model for Resident-report worst pain	<i>N=296</i>		<i>N=259</i>	
Baseline value	-0.51±0.05	<0.001	-0.53±0.06	<0.001
MDS pain frequency			0.60±0.18	0.001
Intervention (vs. Control)	0.26±0.28	0.4	0.91±0.27	0.002

⁺The coefficient is the change in the postinterventions score per 1 unit increase or decrease in the noted pain score. SE: Standard Error

Linear mixed model. Covariates selected by forward selection ($p < 0.05$) and treatment (treatment vs. control) was then added into the model.

* CNA: certified nursing assistant

Table 5

Chart Audit Tool (CAT) summary scores by treatment group and time point.

	CAT Assessment score (%)	CAT Treatment score (%)	CAT Total score (%)
	<i>mean±SE</i>	<i>mean±SE</i>	<i>mean±SE</i>
Control (N=180)			
Baseline (A)	27.5±3.2	65.0±1.3	44.3±2.1
Immediate postinterventions (B)	29.8±3.1	66.2±1.3	45.8±1.7
6-month follow-up (C)	28.3±3.3	66.3±1.8	45.4±2.0
Difference, B-A	2.7±2.8	1.0±1.0	1.6±1.9
Difference, C-A	2.0±2.3	1.4±1.5	1.6±1.6
Intervention (N=202)			
Baseline (A)	32.2±2.3	66.4±2.1	47.4±1.4
Immediate postinterventions (B)	35.7±2.2	67.9±2.4	50.1±1.4
6-month follow-up (C)	39.9±3.2	66.6±2.0	52.1±2.2
Difference, B-A	3.5±2.4	1.2±1.2	2.6±1.4
Difference, C-A	7.5±2.0	0.2±1.1	4.6±1.3
Intervention – Control *			
Difference, B-A	0.7±3.7	0.2±1.6	1.0±2.3
	(p=0.9)	(p=0.9)	(p=0.7)
Difference, C-A	5.0±3.0	-1.2±1.8	2.8±2.1
	(p=0.11)	(p=0.5)	(p=0.2)

* Difference (Intervention minus Control) of differences (postinterventions minus baseline, either B–A or C–A)

Limited to subjects with summary score at each of the three time points. Linear mixed model.