Development and Implementation of an Individualized Turning Program for Pressure Injury Prevention Using Sensor Technology in Nursing Homes: A Quality Improvement Program

Jeanine Maguire, MPT, CWS; Denine Hastings, RN, BSN, MBA; Mary Adams, RN-MSN, APRN, CLNC, FNC; Debra Phillips, RN, BS; John McKenna, BS, MBA; Jiunn-Ru (Angela) Lin, MS; and Annemari Cooley, MA, MBA

ABSTRACT

BACKGROUND: Turning nursing home residents every 2 hours has been a long-held standard for pressure injury (PrI) prevention in individuals with mobility impairments although evidence to substantiate this practice is limited. New guidelines recommend personalizing turning schedules to support person-centered care but lack specific recommendations about which turning frequencies are appropriate for various risk levels. **PURPOSE:** This quality improvement program aimed to determine the feasibility and outcomes of using individualized turn schedules for newly admitted nursing home residents. **METHODS:** An expert panel of wound clinicians developed, tested, and implemented a turn frequency tool that allowed staff in 2 nursing homes to select a turning schedule of 1, 2, 3, or 4 hours based on resident risk factors. Turning schedules were operationalized using a wearable sensor-based visual cueing technology that alerted staff to resident repositioning needs. Nonparticipating resident data were collected for comparison of PrI incidence. Descriptive statistics were calculated for all covariates. Significance of differences tests were performed as appropriate. **RESULTS:** Over 7 months, 154 residents had their turn period individualized, with 56% qualifying for 3-hour (Q3H) or 4-hour (Q4H) schedules. Facility-acquired PrI incidence was 94% lower in participants than in nonparticipants ($P < .0001$). Use of 3-hour and 4-hour intervals saved roughly 21 and 35 minutes of staff time, respectively, per resident per shift. **CONCLUSION:** Individualizing turning schedules is feasible. Residents with longer turning intervals did not develop PrIs, supporting previous studies about safely extending turning periods for most residents.

KEY WORDS: pressure ulcer, pressure injury, pressure injury prevention, quality improvement, patient care, long-term care, nursing care, turning and positioning, nursing intervention

INDEX: *Wound Manag Prev.* 2021;67(11):12–25 doi:10.25270/wmp.2021.11.1225

FINANCIAL DISCLOSURES: This quality improvement program was funded by Genesis Healthcare. Ms Maguire, Ms Hastings, Ms Adams, Ms Phillips, and Mr McKenna are employees of Genesis Healthcare. Ms Cooley and Ms Lin are employees of Smith+Nephew, the manufacturer of the sensor technology used in the program.

A 2-hour turning protocol has been considered a standard of pressure injury (PrI) prevention since Florence Nightingale first implemented the strategy at a Crimean War hospital in the 1850s. Since then, it has become standard practice that all patients and residents at risk for PrI are turned every 2 hours (Q2H), regardless of patient/resident preferences and risk factors, facility type, and level of care, and despite limited scientific evidence on its effectiveness. Further, sleep-wake disturbances have been shown to delay wound healing.[1] They are known to contribute to cognitive decline, delirium, and even the progression of dementia and Alzheimer's disease,[2,3] indicating that around-the-clock bi-hourly turning can be harmful to resident well-being in nursing homes.

Since 2000, several studies in the postacute care population have examined whether equivalent or better PrI outcomes could be achieved with extended turning intervals. In 2005, DeFloor et al[4] studied

Ms Maguire is Vice President, Skin Integrity and Wound Management, Ms Hastings is Sr Director Clinical Product- IT, Ms Adams is Sr Director of Clinical Risk Management, Ms Phillips is Director Clinical Product- IT, and Mr McKenna is Senior Clinical Product Line Manager, Genesis Healthcare, Quakertown, PA. Ms Lin is a Statistician and Data Analyst, Smith+Nephew, Pleasanton CA. Ms Cooley is Sr Director, Clinical Development, Smith+Nephew, Fort Worth, TX. Address all correspondence to: Jeanine Maguire, MPT, CWS, 1140 Virginia Way, Quakertown, PA 18951; tel. 267-733-3178; email: jeanine.maguire@genesishcc.com.

Q2H, 3-hour (Q3H), 4-hour (Q4H), and 6-hour (Q6H) turn intervals with 2 different mattress types in 838 nursing home residents. The study randomized residents into 4 experimental groups (Q2H, Q3H, Q4H, and Q6H turning schedules) and 1 standard care group using 2 different mattress types over 4 weeks. The study concluded that Q4H turning on viscoelastic mattresses resulted in a lower in-house acquired PrI rate and was a more feasible and cost-effective method for PrI prevention than more frequent turning schedules regardless of the mattress type. In 2013, Bergstrom et al[5] conducted a cluster-randomized clinical trial in 27 nursing homes and 942 residents in the United States and Canada, examining PrI incidence with Q2H, Q3H, and Q4H turning schedules using high-density viscoelastic foam mattresses. The study found no difference in PrI incidence among the Q2H, Q3H, and Q4H turning groups. Researchers later determined that using Q3H and Q4H turning intervals is more cost-effective per nursing home resident across their lifetime than using the traditional Q2H turning schedule for all.[6] Most recently, Yap et al[7] undertook a cluster-randomized clinical trial in 9 US nursing homes to compare outcomes among Q2H, Q3H, and Q4H turning protocols, the results of which are pending publication.

Meanwhile, clinical practice guidelines since 2014 have advanced to recommend "individualizing the turning and repositioning schedule," ensuring that it is "consistent with the individual's goals and wishes, current clinical status, and combination of comorbid conditions, as medically feasible."[8] This reflects an acceptance of evidence-based turning frequencies beyond the standard Q2H interval for all; however, the guidelines offer no specific guidance to direct clinicians about determining the most appropriate frequency for each individual. Without this guidance, caregivers and residents are left with their best guess in selecting a frequency. For fear of litigation, many default to the Q2H rule for all rather than implementing an individualized program for each.

Individualizing the turn frequency is aligned with person-centered care rather than a one-size-fits-all intervention. It acknowledges the individual's unique needs and circumstances for PrI prevention and management, including their PrI risk, skin health, mobility level, and tissue tolerance. For example, some individuals with a preexisting PrI may benefit from a more frequent turning schedule to offload and provide more frequent pressure redistribution to damaged tissues, whereas those with lower risk and healthy skin may benefit from longer turning schedules. This individualization may improve resident sleep hygiene while also allowing for better allocation of nursing time.

Despite the evidence supporting clinical efficacy and economic benefits of longer turning frequencies, a significant gap in the literature exists regarding how to select individualized turn periods and how to operationalize such a program. Traditional reminders, such as paper clocks, have reinforced keeping residents turned to a specific side based on the time of day. Musical chimes played over the intercom have been studied[9] as a reminder system to improve adherence to a Q2H turning schedule. However, neither of these methods would easily lend themselves to managing several different turning schedules based on individual resident risk and mobility level. While many studies have demonstrated that adherence to turning protocols is low regardless of the health care setting,[9-14] adhering to the turn protocol arguably becomes more critical as turning intervals are extended. For this study, wireless accelerometer-based sensor technology was used to help staff track each resident's repositioning needs and monitor protocol adherence.

Aims. The aims of this QI program were to 1) develop a turning frequency selection tool based on existing evidence and clinical expert opinion, 2) assess the feasibility of operationalizing individual turning schedules using the tool by measuring adherence to the turning schedules, 3) determine whether individualized turning schedules improve clinical outcomes by comparing facility-acquired PrI rates in QI participants with those of nonparticipants, and 4) measure the difference in required staff time by comparing the staff time turning residents per individual schedules to the time that would have been spent with a universal Q2H schedule.

KEY POINTS

- New guidelines recommend personalizing turning schedules to support person-centered care but lack specific recommendations about which turning frequencies are appropriate for various risk levels.
- A quality improvement program to determine the feasibility and outcomes of using individualized turn schedules for newly admitted nursing home residents was implemented at the authors' institution.
- Over 7 months, 154 residents had their turn period individualized, with 56% qualifying for 3-hour or 4-hour schedules. Facility-acquired PrI incidence was 94% lower in participants than in nonparticipants ($P < .0001$).
- The results of this study indicate that the implementation of individualized turning schedules is feasible, safe, and may help reduce nursing staff time.

METHODS

The QI project was conducted from July 2019 through April 2020 and consisted of 2 phases. First, the turn frequency tool was developed in July and August 2019, field-tested by nursing home staff in September 2019, and revised based on feedback. Second, the individualized turn frequency tool was implemented as a QI in September and October 2019 using a wireless, patient-wearable sensor system to operationalize the program.

Ethical considerations. The initiative was implemented as a QI for individualizing and monitoring a previously established turning and repositioning program. The QI initiative received approval from the nursing home company's skin integrity practice council. Physician orders were obtained for each participating resident

Table 1. Initial Version of the Turning Frequency Tool Identifying Risk Factors That Influence Turn Regimen

Turn frequency	Patient risk factors	Additional guidance
Q1H	• 2 or more PrIs on 2 or more turning surfaces • 1 large PrI that cannot be offloaded with positioning	
Q2H	• Any single PrI, any stage, on only 1 turning surface • Totally dependent and/or bedfast	Refer to Braden scale
Q3H	• No current PrI **AND** • Limited mobility **OR** • Sensory/cognitive impairment	Refer to Braden scale Refer to MDS[a]
Q4H	• No current PrI, no history of PrI, **AND** • Limited ambulation or chair-fast **OR** • Impaired sensation/cognition	Refer to Braden scale
No schedule	• No PrI risk factors • 100% independent with daily ambulation • No cognitive impairment • No sensory impairment • No history of PrI **OR** • Resident opts out of program • Adhesive allergy (given LEAF sensor)[b]	No PrI risk factors

Abbreviations: MDS, minimum data set; PrI, pressure injury; Q1H, every hour; Q2H, every 2 hours; Q3H, every 3 hours; Q4H, every 4 hours.
[a]Long-term care MDS by Centers for Medicare and Medicaid Services.
[b]LEAF Patient Monitoring System; Smith+Nephew, Pleasanton, CA.

for sensor placement and visual cueing of staff to individual resident repositioning needs. As with any nursing intervention, residents maintained the right to refuse or opt out of the program at any time. Residents who qualified for the program and/or their family members were asked if they would like to voluntarily participate in the PrI prevention program and were told that the resident would be wearing a sensor on their chest to help staff identify when they needed assistance turning. Verbal consent was obtained from the resident or family if the resident could not consent due to a medical condition. All resident and sensor data were deidentified before analysis by replacing the resident's name and medical record number with a system-generated patient identification number to safeguard confidentiality and protect health information.

Participants. The Centers for Medicare and Medicaid Services (CMS) State Operator's Manual for surveyors of long-term care facilities specifically calls out newly admitted nursing home residents as the most vulnerable for PrI, stating that 96% of PrIs develop in the first 3 weeks of admission.[15] Therefore, the QI program was implemented as standard of care for 1) all newly admitted residents due to their increased risk for PrI development during the first 3 weeks of their nursing home stay,[15,16] 2) residents with preexisting pressure injuries due to their increased risk for developing additional PrI,[8] and 3) residents with deteriorating condition per nursing judgment. Residents with an adhesive allergy were excluded because the wearable sensors used to operationalize the program attached to the body with adhesive film. At the end of the 3 weeks, nursing staff could decide whether the resident's condition warranted continuing an individualized turning schedule and sensor monitoring. Residents who resided at the 2 facilities during the QI program and who did not qualify for the QI program or who met the exclusion criteria ("nonparticipants") were assigned standard care based on their risk factors. Guidelines for this standard care were outlined in the facilities' skin care policy and included such standard interventions as individualized turning schedules without sensor monitoring, therapeutic support surfaces, routine skin checks, and other basic nursing interventions.

Setting. The program was made available for nursing homes located in the Northeastern United States belonging to a national nursing home chain. The infrastructure to support the wireless technology was a requirement of participation, limiting the possible nursing home facilities to 9. Next, the nursing homes were selected based on their willingness to participate and overall staffing stability, including a designated skin integrity program lead and experience with participating in QI programs.

Nursing Home 1 (NH1) was a 238-bed skilled nursing facility located in an urban setting. The mean resident age in the facility was 64 years, with 52% male residents at the start of the project. The facility was under contract with US Department of Veterans Affairs and had specialized programs for veterans. Nursing Home 2 (NH2) was a 180-bed suburban facility whose residents

Room	Patient	Time Until Next Turn	Position	Information
2301	M.S.	1:57	L [B] R	Upright
2302	C.M.	0:14	[L] B R	
2303	S.S.	Turn Due 0:03 Over	L B [R]	
2304	M.L.	1:51	L B R	Prone

Figure 1. LEAF Display Cues

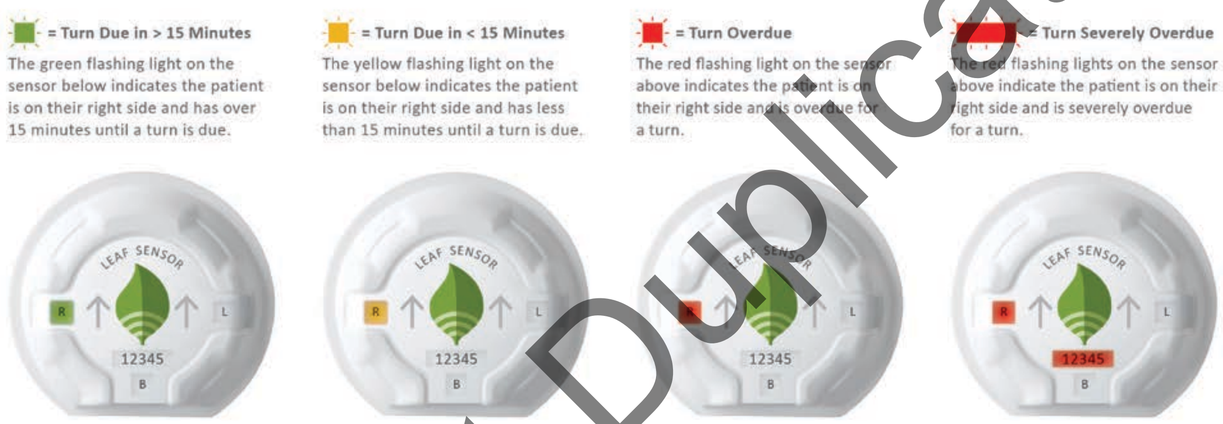

Figure 2. LEAF Sensor Showing Indicators for Turning Status

had a mean age of 77 years and were 29% male. Both nursing homes had short-stay and transitional care units for posthospitalization rehabilitation, and both offered long-term and respite care services. Both facilities were rated as average in resident care quality and above or much above average in staffing by Medicare.gov.

Turn frequency tool development. The development of the turn frequency tool and evaluation of its content and face validity was based on Lynn's guidelines.[17] The nursing home company's skin integrity practice council, an interprofessional group of 8 wound experts, developed the tool and field-tested it to ensure its construct was appropriate.[18] The group consisted of 5 registered nurses (RNs), a dietitian, 2 physical therapists, and 1 nurse practitioner who also worked as a risk and quality manager. All participants had wound expertise and a minimum of 10 years of wound management experience.

A literature search was conducted using MEDLINE, ERIC, Sage Knowledge, Science Direct, Sage Journals, and Google Scholar. The keywords for the search included pressure ulcer, pressure injury, chronic wound, post-acute care, long term care, skilled nursing, nursing home, and turning and repositioning. Three published studies[4,5,19] and 2 literature reviews[20-22] about repositioning frequencies were reviewed along with PrI clinical practice guidelines.[23] None of the reviewed evidence suggested which turning frequencies are most beneficial for PrI prevention in specific risk groups. The guidelines offered no information about how turning frequency individualization should occur. The skin integrity practice council then proceeded to evaluate literature about PrI risk factors, such as advanced age, mobility impairment, PrI history, moisture, friction and shear, nutritional impairment, and cognitive or sensory impairment along with various comorbidities commonly seen in the nursing home population. Nine (9) studies were reviewed, including some classic works[24-32] about PrI risk in the elderly in the specific context of turning and repositioning. Immobility, cognitive and sensory-related deficits, and the size, location, and stage of a preexisting PrI were most important in influencing a turning schedule. The skin integrity council discussed recommendations for selecting turning frequencies based on those risk factors and finalized the tool when a 100% consensus was achieved (Table 1). Interrater reliability of the turning frequency tool was tested in NH1 with 20 clinicians. The turn frequency tool was presented to a group of RNs and licensed practical nurses (LPNs) to discuss and determine face validity. This team agreed on the concept, risk factors, and the guidelines for selecting a turning period.

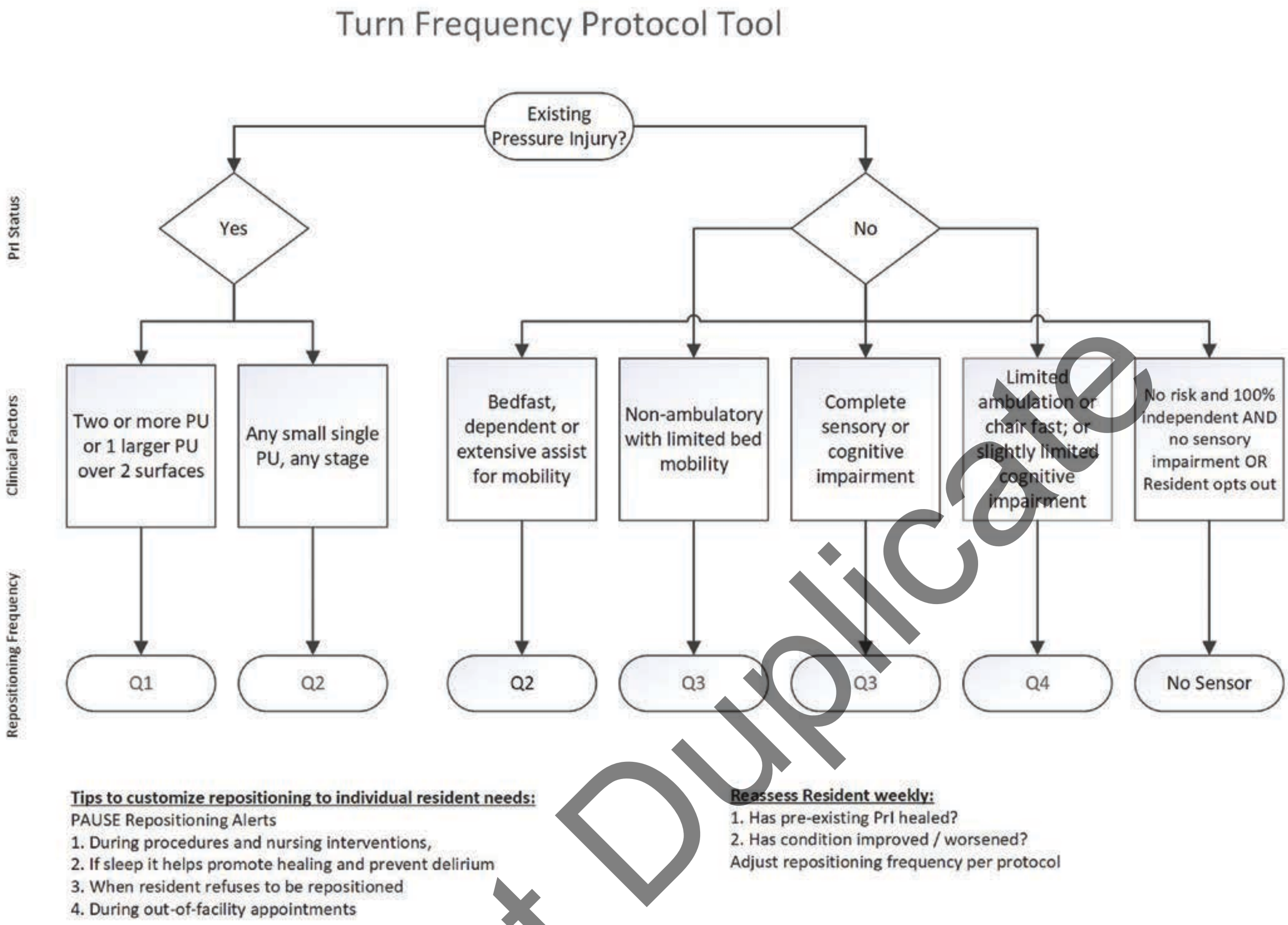

Figure 3. Turn Frequency Protocol Tool

Instrument. A resident-wearable sensor system (LEAF Patient Monitoring System; Smith+Nephew, Pleasanton, CA) was used to operationalize the program. The system consisted of an accelerometer-based sensor that was worn on the resident's upper torso and wirelessly transmitted data regarding the resident's position or ambulation status and time until next turn on monitors placed throughout hallways and on nursing stations. The technology provided silent, visual cues to alert staff about individual resident repositioning needs and had been shown to help nursing staff sustain a high adherence to the prescribed turn protocol[10,12] and reduce facility-acquired PrI.[19] A green color indicated that no turn was due, a yellow color indicated turn was due within 15 minutes, and red indicated that a turn was overdue (Figure 1). The resident's turning status could also be cued by lightly tapping the sensor (Figure 2). If a resident moved sufficiently on their own, the turn cue would automatically reset to green to avoid unnecessary staff intervention. Visual turn cues could be paused for 1 to 4 hours if repositioning could not be performed on time by indicating a reason for the delay. The technology automatically documented all position changes and reasons for delayed turning attempts, such as resident refusals, which could allow the clinical team to target resident/family discussions or additional staff education about PrI prevention and management.

Program implementation. Prior to the QI initiative launch, the nursing home staff received 30 minutes of classroom education about PrI risk factors, skin assessment, tissue tolerance, the turn frequency tool, and how to use the sensor technology deployed to operationalize the program. The 6 case studies used for reliability testing were provided to assess the competency of each participant with an expectation that the correct individualized turn frequency would be selected by using the tool. A score of 100% was required to pass. In addition, the nursing staff was provided resident and family education resources about the program and background on the importance of turning and repositioning for PrI prevention.

To encourage high adherence to the visual turn cues, nursing home champions received via email a daily report generated by the equipment manufacturer with data on the previous day's facility turn protocol adherence for each unit and shift. The aggregated, deidentified reports also included information about pausing trends and percent of monitoring time while patients were in supine, lateral, or upright positions. Additionally, facility champions received monthly QI reports indicating

Table 2. Resident Characteristics

Resident characteristics	NH1 participants (n = 43)	NH2 participants (n = 111)	Total participants (N = 154)	Nonparticipants (NH1 and NH2) (N = 571)	*P* value[a]
Mean resident age, y (SD)	64.3 (16.2)	76.9 (10.8)	73.4 (13.7)	68.7 (16.8)	**< .001**
Range	24–96	44–98	24–98	21–108	
Age by CMS Group, n (%)					**< .001**
19-44	6 (14%)	1 (1%)	7 (5%)	45 (8%)	
45-64	16 (37%)	12 (11%)	28 (18%)	196 (34%)	
65-84	14 (33%)	69 (62%)	83 (54%)	215 (20%)	
≥85	7 (16%)	29 (26%)	36 (23%)	115 (20%)	
Male participants, n (%)	25 (58%)	58 (52%)	83 (54%)	236 (41%)	**.003**
Facility resident male sex, n (% of total resident population)	178 (49%)	58 (29%)		236 (41%)	
Race					**.004**
White non-Hispanic, n (%)	25 (58%)	93 (84%)	118 (77%)	355 (62%)	
Black, not of Hispanic origin	14 (33%)	6 (5%)	20 (13%)	114 (20%)	
Hispanic or Latino, n (%)	3 (7%)	1 (1%)	4 (3%)	27 (5%)	
Native Hawaiian, Pacific Islander	1 (2%)	1 (1%)	2 (1%)	2 (0.4%)	
Unknown or other	0 (0%)	10 (9%)	10 (6%)	73 (13%)	
Admission Braden Scale score, mean (SD)	17.2 (3.3)	17.2 (2.8)	17.2 (2.9)	18.3 (3.0)	**.001**
Range	9-22	11-22	9-22	8-23	
Residents w/o Braden Scale score, n (%)	15 (35%)	21 (19%)	396 (23%)	74 (13%)	
Admission MDS M0150 risk of developing PrI, n (%)	38 (88%)	98 (88%)	136 (88%)	443 (78%)	**.002**
Body mass index, mean (SD)	28.1 (12.6)	29.0 (8.5)	28.7 (9.8)	28.4 (10.2)	**.306**
Range	14-77	14-61	14-77	10-94	

Abbreviations: CMS, Centers for Medicare and Medicaid Services; MDS, minimum data set; NH1, nursing home 1; NH2, nursing home 2; PrI; pressure injury; QI, quality improvement; SD, standard deviation.
[a]Significance of differences between QI participants and the nonparticipating nursing home population was determined using Wilcoxon signed rank test for continuous variables and Fisher's exact test and z test for categorical variables.

Table 3. Participants and Turning Patterns by Facility

Participant and monitoring data	NH1 (n = 43)	NH2 (n = 111)	Total (N = 154)
Reason for enrollment, n (%)			
New admission	30 (70%)	85 (77%)	115 (75%)
Existing wound or deteriorating condition	13 (30%)	26 (23%)	39 (25%)
Primary diagnoses on admission	1. Medical management 2. Cardiovascular and coagulations		
Total protocol time, h	19 383	52 140	72 524
Protocol days per resident, mean (SD)	18.8 (27.8)	19.6 (26.1)	19.4 (26.5)
Range	7 h–135 d	1 h–171 d	1 h–171 d
Median	10.2	11.0	10.9
Adherence to turn protocol, mean (SD)	0.84 (0.16)	0.88 (0.12)	0.87 (0.13)

Abbreviations: NH1, nursing home 1; NH2, nursing home 2; SD, standard deviation.

turn alert pausing, overall center and unit turn protocol adherence, and the number of residents and care hours monitored. Monthly conference calls were held with both nursing homes' program champions to discuss the reports, review the data, and answer any questions relating to the turn frequency tool or the QI program.

Measures. Resident demographic data were extracted from the facilities' electronic health record (EHR) for the QI participants and concurrent nonparticipants in the 2 facilities by the nursing home company's clinical informatics staff using SQL Server Management Studio version 18.7. The data included sex, race, age, and factors related to PrI risk, such body mass index, admission Braden Scale score, presence of preexisting PrI at admission, and CMS Minimum Data Set pressure injury risk assessment measure (M0150). Primary and secondary International Classification of Disease-10 diagnoses were also collected and categorized for comparison across groups. PrIs that developed during the QI period were also extracted from the facilities' EHR using SQL Server Management Studio version 18.7. Analysis of PrIs that developed during the QI program were limited to turning surfaces, defined as the trunk (including scapulae), the lower back, spine, trochanters, ischial tuberosities, the iliac crest, gluteus, buttocks, sacrum, and coccyx. Heel and device-related PrI were excluded as they require different prevention strategies. Clinical informatics staff and the nursing home company's vice president for skin and wound reviewed each PrI for body location and stage by using the revised National Pressure Ulcer Advisory Panel staging system[33] to assess wound documentation and photographs in the EHR. PrIs were counted for program participants and contemporary nonparticipants in the 2 nursing homes for the duration of their participation. The incidence was derived by dividing the number of PrIs occurring in both groups by the total number of residents.

Resident position and ambulation data were transmitted by each sensor on average every 10 to 30 seconds and stored in an SQL database on a server located at the nursing home company's administrative facility. Each sensor transmission consisted of a set of timestamped accelerometer measurements. A reporting tool program, part of the sensor system software, connected to the database to deidentify and process the stored sensor data and then calculate position angle values to determine changes to resident orientation. The program output a sequential list of entries that contained the orientation and duration in a comma-delimited (.CSV) file format. Turn protocol adherence was calculated by dividing adherent ("green") time to an individual's turning schedule by total monitoring time (adherence (%) = [total time resident was adherent to turn protocol / total time monitored]) × 100). The turn protocol adherence to each participant's individual turning schedule was calculated from the comma-delimited files and aggregated for each facility and turn protocol group using a Python (version 2.7.16) script.

The difference in staff time compared with the standard Q2H schedule was calculated using the number of per-resident protocol days and achieved adherence to the assigned turning frequency. The mean number of achieved resident turns per shift was deducted from the number of turns achieved in the Q2H protocol group and multiplied with an assumption of 16 minutes[34] of staff time to complete each resident repositioning event.

Statistical analysis. Descriptive statistics were calculated for all covariates, and the significance of differences were performed using several methods. A z test

Table 4. Resident Characteristics by Turning Schedule

	Primary Turning Schedule				
Resident characteristics and turning patterns by turning schedule	**Q1H (n = 4)**	**Q2H (n = 64)**	**Q3H (n = 30)**	**Q4H (n = 56)**	***P* value**
Mean resident age, y (SD)	62.5 (26.0)	72.7 (13.2)	74.9 (12.9)	74.1 (13.8)	**.463**
Range	36–98	35–96	40–93	24–98	
Age by CMS group, n (%)					**.403**
19–44	1 (25%)	3 (5%)	1 (3%)	2 (4%)	
45–64	2 (50%)	12 (19%)	5 (17%)	9 (16%)	
65–84	0	33 (52%)	18 (60%)	32 (57%)	
≥ 85					
1 (25%)	16 (25%)	6 (20%)	13 (23%)		
Male, n (%)	3 (75%)	33 (52%)	17 (57%)	30 (54%)	**.856**
Race					**.353**
White non-Hispanic, n (%)	3 (75%)	50 (78%)	20 (67%)	45 (80%)	
Black, not of Hispanic origin	1 (25%)	9 (14%)	7 (23%)	3 (5%)	
Hispanic or Latino, n (%)	0	2 (3%)	1 (3%)	1 (2%)	
Native Hawaiian or Other Pacific Islander	0	1 (2%)	0	1 (2%)	
Unknown	0 (0%)	2 (3%)	2(7%)	6 (11%)	
Braden Scale score on admission, mean (SD)	18 (N/A)a	16 (2.9)	17 (2.4)	18.3 (2.8)	**.001**
Range	N/A	9-21	13-22	11-22	
Residents missing a Braden Scale score, n (%)	3 (75%)	21 (33%)	1 (3%)	11 (20%)	
Body mass index, mean (SD)	29.7 (9.6)	27.8 (8.6)	31.3 (13.7)	28.4 (8.5)	**.927**
Range	22–44	14–51	18–77	14–56	
Protocol days per resident, mean (SD)	24 (30)	22.6 (33)	17.4 (19.5)	16.3 (20.3)	**.688**
Median	13.4	10.5	12.7	9.9	

Continued on next page

Table 4. Resident Characteristics by Turning Schedule (*Continued*)

Resident refusals to turn,					
% protocol time	9%	5%	5%	4%	**.125**
Adherence to turn protocol, mean (SD)	66% (0.18)	84% (0.14)	89% (0.09)	90% (0.12)	**<.001**
NH1	53% (0.14)	82% (0.16)	89% (0.08)	96% (0.06)	.011
NH2	79% (0.08)	85% (0.13)	89% (0.10)	90% (0.12)	.020

Abbreviations: CMS, Centers for Medicare and Medicaid Services; NH1, nursing home 1; NH2, nursing home 2; SD, standard deviation.
[a]Two (2) of 3 residents were missing an admission Braden Scale score. Kruskal-Wallis test was used to determine significance of difference for continuous variables, and Fisher's exact test was used for categorical variables. Dunn's Multiple Comparison test was used to test the difference between turn periods if the overall difference was significant.

was used for categorical covariates with large samples, whereas the Fisher exact test was used for categorical covariates with small samples. The Wilcoxon signed-rank test was used for continuous covariates that were not normally distributed. The Kruskal-Wallis test was used to determine if there was a difference between groups for continuous covariates that were not normally distributed. Lastly, the Dunn multiple comparison test was used for identifying groups with significant differences after the Kruskal-Wallis test was performed. Tables were annotated with the names of each test performed. Statistical analyses for all data were performed using R (version 4.0.3) within RStudio (version 1.3.1093). Results were considered statistically significant if $P < .05$.

RESULTS

Tool reliability. To field test the turn frequency tool, 6 case studies were developed to include the designated risk factors. Groups of volunteer RNs and LPNs from NH2 were provided the case studies and asked to determine the turning regimen they would select for each case individually. The first group of 11 nurses completed this task in less than 10 minutes and determined the same response in 5 out of 6 cases. The group then engaged in conversation to determine the reasons for a different protocol selection in the outlier case study. This prompted minor wording changes in the turn frequency tool to eliminate confusion and provide the information in an algorithm format to improve user ease and accuracy in selecting the correct turning schedule (Figure 3). The information in the tool was then converted by the project team into an algorithm, allowing a nurse to first select the resident's clinical factors, including the presence of preexisting PrI, which then led to the recommended turning schedule.

The new algorithm was tested on a different group of 23 RNs, LPNs, and physical therapists. Each clinician was provided the same 6 case studies, which included key risk PrI factors influencing turning, and the individuals were asked to work independently to determine the correct turning frequency. All participants completed this task in less than 10 minutes with 100% accuracy in selecting the individualized turn frequency.

Feasibility of individualizing turning schedules. From September 2019 through March 2020, a total of 154 residents in NH1 and NH2 had their turning frequency individualized using the turning frequency tool, while a total of 571 residents either did not qualify or chose not to participate in the program and were assigned standard care (Table 2). The urban NH1 had a much younger resident population and a higher percentage of male residents than the suburban NH2. The facility also had fewer new admissions during the QI period, which resulted in significantly fewer participants in NH1 than NH2.

Seventy-five percent (75%) of participants were new admissions, and 25% qualified for the program due to a preexisting PrI or a deteriorating condition. Length of program participation per resident ranged from 1 hour to 171 days, with a mean of 19.4 days and a median of 11 days (Table 3). Eight (8) residents (5%), 5 of whom were female, wanted to discontinue their participation within the first 24 hours; of these, 4 were assigned to a Q2H schedule and 4 were assigned to a Q4H schedule.

More than half of the program participants were assigned to either Q3H or Q4H as their primary turn period (Table 4). Turn protocol adherence in QI participants varied by the facility and assigned turning frequency but not by age or other resident characteristics. The lowest mean protocol adherence of 66% was in residents assigned Q1H turning. Adherence increased as turning interval duration increased. Mean adherence for Q2H participants was 84%, higher than previously reported in literature[12,13,35] for long-term care. Mean adherence was 89% for Q3H participants and 90% for Q4H participants, which was significantly higher than that seen in the Q2H ($P = .003$) and Q1H ($P = .001$, Table 4) groups. Turn adherence was not measured for residents who did not participate in the QI program as they were not assigned sensor monitoring.

After 7 months, the program ended in April 2020 due to the overwhelming need to focus on COVID-19 pandemic–related management and infection control.

Clinical outcomes. Residents participating in the QI project in both nursing homes were older than nonparticipating residents and had lower admission Braden Scale scores with a higher percentage

Table 5. Pressure Injuries

Pressure injuries	**NH1 (n = 43)**	**NH2 (n = 111)**	**Total participants (N = 154)**	**Concurrent nonparticipants (N = 571)**	***P* value[a]**
PrI present on admission, n (%)	8 (19%)	18 (19%)	26 (17%)	67 (12%)	0.63
New PrI during QI project, n (%)[b]	0 (0%)	1 (0.9%)	1 (0.7%)	71 (12.4%)	<.001
PrI on Q1H	0	0	0		
PrI on Q2H	0	1	1		
PrI on Q3H	0	0	0		
PrI on Q4H	0	0	0		

Abbreviations: NH1, nursing home 1; NH2, nursing home 2; PrI, pressure injury; Q1H, every hour; Q2H, every 2 hours; Q3H, every 3 hours; Q4H, every 4 hours; QI, quality improvement.
[a]Significance of difference between QI participants and nonparticipants was determined using z test.
[b]Pressure injury incidence during QI period was limited to turning surfaces, defined as trunk including scapulae, the lower back, and spine; trochanters, ischial tuberosities, the iliac crest, gluteus, buttocks, sacrum, and coccyx.

of being coded as being at risk for PrI per MDS M0150 risk score (Table 2). Male sex and White non-Hispanic race also were more common in the participants than in nonparticipants in both nursing homes. The incidence of new facility-acquired PrI on turning surfaces was 0.7% in the QI participants at both nursing homes compared with 12.4% in the nonparticipants ($P < .001$, Table 5). One in-house–acquired sacral PrI occurred in NH2 in a resident receiving hospice care and assigned to a Q2H turning schedule. The resident was a new admission and placed on a Q2H turning schedule due to preexisting "nonblanchable redness" on the buttocks documented on the day of admission and at a bedfast mobility level. The resident remained on the program for 27 days until the end of life. A sacral unstageable PrI was documented the same day the resident died. Given the resident's overall decline and 7.5% weight loss, it is likely that the worsening of this wound, which was not documented as a stage 1 PrI, was a result of end-of-life skin failure. The actual mean time between turning for the resident was 3.7 hours (54% adherence to the 2-hour turning schedule). During the individual's stay, 75% of their time was spent in the supine position, 11% in lateral recumbent, and 14% in an upright (sitting) position.

Staff time. Theoretically, the use of longer turn periods allowed staff to better allocate their time to perform other resident care activities. While the Q1H protocol added an estimated 48 minutes of staff time to each 12-hour shift per resident, the Q3H schedule freed up roughly 21 minutes, and the Q4H schedule freed up 35 minutes of staff time per resident per shift (Table 6). While savings in staff time are difficult to translate into tangible economic savings, they allow for more flexibility in allocating scarce resources while maintaining a high degree of adherence to each resident's turning schedule.

DISCUSSION

This program demonstrated that individualization of turning schedules is feasible and safe in the nursing home setting. PrI incidence among the program participants was very low despite more than half of the participants being on a Q3H or Q4H turning schedule. The participants were older and at higher PrI risk based on their Braden Scale scores and MDS risk assessment measures than those who did not participate in the program, yet they had a lower incidence of PrI. Compared with nonparticipants, more residents participating in the QI program were male. The authors cannot explain any possible reasoning for this difference because no detailed records were kept about the number or gender of residents who declined to participate in the voluntary program. Anecdotally, however, the facilities reported that female residents were concerned about the sensor being visible when wearing lower-cut blouses, hence having the exposed medical device look like a "badge of disability."

This QI program was the first of its kind to implement a tool to individualize turn periods based on resident needs and risk factors, as recommended in the 2019 Clinical Practice Guidelines for Pressure Injury Prevention and Management.[8] The use of extended turning periods resulted in no new in-house–acquired sacrococcygeal PrI in residents assigned to Q3H or Q4H turning schedules, which supports previously published findings by DeFloor et al[4] and Bergstrom et al[5] about safely extending turning periods for the majority of NH residents. The program was well-received by staff, who reported that the sensor data helped them prioritize tasks, improve

Table 6. Estimated Staff Time Savings by Turn Frequency and Achieved Adherence Compared With Q2H Schedule

	Estimated staff time saved per protocol			
	Q1H	**Q2H**	**Q3H**	**Q4H**
Number of participants	4	64	30	56
Number of protocol days per resident, mean	24	23	17	16
Total monitoring hours	2318	34 709	12 533	21 963
Number of prescribed turns based on protocol (monitoring hours × protocol)	2318	17 355	4178	5498
Measured protocol adherence, mean	66%	84%	89%	90%
Mean number of achieved turns (prescribed turns × adherence)	1530	14 578	3718	4948
Number of actual turns per resident, mean	382	228	124	88
Turns per shift, mean (protocol days/mean turns per resident/2)	8.0	5.0	3.6	2.8
Difference in the number of turns per shift compared with Q2H, mean	-3.02	0	1.3	2.2
Time saved/(increased) per resident per shift in minutes, mean[a]	(48.3)	0.0	20.9	35.0

Abbreviations: Q1H, every hour; Q2H, every 2 hours; Q3H, every 3 hours; Q4H, every 4 hours.
[a]Assumption used to calculate time requirement for each resident turn was 16 minutes

teamwork, and discuss PrI prevention with residents and their families. Program leads at the nursing homes also reported that residents regarded the initiative favorably. Adherence to the Q2H, Q3H, and Q4H turning schedules remained high during the program, ranging from 82% to 96%, and visual turn cues and daily reporting about turn protocol adherence likely created a Hawthorne effect that helped staff maintain a high level of adherence to resident turning schedules. The use of longer turning periods allowed staff to prioritize their time for other care activities while maintaining a high adherence to everyone's turning schedule. The Q1H turn period, which was used to manage residents with preexisting multiple or large multisurface PrIs, proved difficult for staff to maintain and for residents to tolerate. Residents assigned to an hourly turning schedule had a significantly lower mean turn protocol adherence than those in the groups with longer turning frequencies, indicating that the staff had difficulty keeping up with hourly turning requirements. Residents assigned Q1H turning were also somewhat more likely to refuse staff-assisted turns than individuals with longer turning periods (9% of protocol time compared to 5% for longer turning periods).

More evidence is needed to help caregivers determine which turning schedules should be selected in different care settings. Further, a validation testing of the turn frequency tool and additional research regarding the safety and benefits of individualized turning for PrI prevention across the health care continuum is warranted.

LIMITATIONS

This initiative was limited by its quality improvement methodology, which lacked the rigor of quasi-experimental or randomized studies. Other limitations included a relatively short duration of protocol participation per resident (mean, 19.4 days), a premature end of the project due to the COVID-19 pandemic at 7 months, and heterogeneity of the 2 participating facilities, which were chosen without seeking homogeneity in their population characteristics.

While the technology provided the practical means of responding to individual resident repositioning needs, wearing an adhesive sensor for the entire duration of a resident's stay in a long-term care facility may not be practical or economically feasible. Therefore, inclusion criteria were limited to residents at highest risk (ie, newly admitted patients for their first 3 weeks of stay and residents with special nursing concerns for PrI management or development). Despite the higher PrI risk profile of the program participants, the PrI incidence in nonparticipants remained relatively high. It is possible that important clinical or social risk factors were missed in the program inclusion criteria, and broader inclusion criteria could have resulted in a lower overall facility

PrI incidence. Lastly, the reliability of the turn frequency tool was not determined. An increased sample size required for a reliability study was out of scope for this QI program.

CONCLUSIONS

A turn frequency tool and algorithm was developed, tested, and implemented as a QI program in 2 nursing homes in the northeastern United States. The program was made available for patients newly admitted to the nursing homes and residents with preexisting PrI or deteriorating conditions and operationalized using a wearable sensor-based technology that provided visual cues to caregivers about each resident's turning and repositioning needs.

More than half the participants qualified for either Q3H or Q4H turning schedules. Adherence to the Q2H, Q3H, and Q4H turning schedules remained high during the program, and visual turn cues and daily reporting about turn protocol adherence likely created a Hawthorne effect that helped staff maintain a high level of adherence to resident turning schedules. The use of longer turning periods allowed staff to prioritize their time for other care activities while maintaining a high adherence to everyone's turning schedule. The Q1H turn period, which was used to manage residents with preexisting multiple or large multisurface PrIs, proved difficult for staff to maintain and for residents to tolerate. Residents assigned to an hourly turning schedule had a significantly lower mean turn protocol adherence than those in the groups with longer turning frequencies, indicating that the staff had difficulty keeping up with hourly turning requirements. Residents assigned Q1H turning were also somewhat more likely to refuse staff-assisted turns than individuals with longer turning periods. Current staffing and reimbursement levels in long-term care may not be sufficient to manage hourly turning, and the benefits of Q1H turning may not outweigh its disadvantages. ■

ACKNOWLEDGMENTS

The authors acknowledge Donna Boyer, Lisa Buettler, Tina Cheftalian, Artemizia Illich, Janelle Klepczynski, Troy Long, Arnold Morgan, Karen Petrucci, Dawn Ranochak, and Tara Winter for their support of this QI program.

REFERENCES

1. Smith TJ Wilson MA, Karl JP, et al. Impact of sleep restriction on local immune response and skin barrier restoration with and without "multinutrient" nutrition intervention. *J Appl Physiol*. 2018;124(1):190–200. doi:10.1152/japplphysiol.00547.2017
2. Fitzgerald JM, O'Regan N, Adamis D, et al. Sleep-wake cycle disturbances in elderly acute general medical inpatients: longitudinal relationship to delirium and dementia. *Alzheimer's Dement (Amst)*. 2017;7:61–68. doi:10.1016/j.dadm.2016.12.013
3. Fultz NE, Bonmassar G, Setsompop K, et al. Coupled electrophysiological, hemodynamic, and cerebrospinal fluid oscillations in human sleep. *Science*. 2019;366(6465):628–631. doi:10.1126/science.aax5440
4. Defloor T, De Bacquer D, Grypdonck MH. The effect of various combinations of turning and pressure reducing devices on the incidence of pressure ulcers. *Int J Nurs Stud*. 2005;42(1):37–46. doi:10.1016/j.ijnurstu.2004.05.013
5. Bergstrom N, Horn SD, Rapp MP, Stern A, Barrett R, Watkiss M. Turning for ulcer reduction: a multisite randomized clinical trial in nursing homes. *J Am Geriatr Soc*. 2013;61(10):1705–1713. doi:10.1111/jgs.12440
6. Pechlivanoglou P, Paulden M, Pham B, Wong J, Horn S, Krahn M. Turning high-risk patients: an economic evaluation of repositioning frequency in long-term care. *J Am Geriatr Soc*. 2018;66(7):1409–1414. doi:10.1111/jgs.15387
7. Yap TL, Kennerly SM, Horn SD, Bergstrom N, Datta S, Colon-Emeric C. TEAM-UP for quality: a cluster randomized controlled trial protocol focused on preventing pressure ulcers through repositioning frequency and precipitating factors. *BMC Geriatr*. 2018;18(1):54. doi:10.1186/s12877-018-0744-0
8. European Pressure Ulcer Advisory Panel, National Pressure Injury Advisory Panel, Pan Pacific Presure Injury Alliance. Prevention and Treatment of Pressure Ulcers: Clinical Practice Guideline. *The International Guideline*. 3rd ed. EPUAP/NPIAP/PPPIA; 2019.
9. Yap TL, Kennerly SM, Simmons MR, et al. Multidimensional team-based intervention using musical cues to reduce odds of facility-acquired pressure ulcers in long-term care: a paired randomized intervention study. *J Am Geriatr Soc*. 2013;61(9):1552–1559. doi:10.1111/jgs.12422
10. Schutt SC, Tarver C, Pezzani M. Pilot study: assessing the effect of continual position monitoring technology on compliance with patient turning protocols. *Nurs Open*. 2018;5(1):21–28. doi:10.1002/nop2.105
11. Pickham D, Pihulic M, Valdez A, Mayer B, Duhon P, Larson B. Pressure injury prevention practices in the intensive care unit: real-world data captured by a wearable patient sensor. *Wounds*. 2018;30(8):229–234.
12. Yap TL, Kennerly SM, Ly K. Pressure injury prevention: outcomes and challenges to use of resident monitoring technology in a nursing home. *J Wound Ostomy Continence Nurs*. 2019;46(3):207–213. doi:10.1097/WON.0000000000000523
13. Moore Z, Cowman S. Pressure ulcer prevalence and prevention practices in care of the older person in the Republic of Ireland. *J Clin Nurs*. 2012;21(3-4):362–371. doi:10.1111/j.1365-2702.2011.03749.x
14. Voz A, Williams C, Wilson M. Who is turning the patients? A survey study. *J Wound Ostomy Continence Nurs*. 2011;38(4):413–418. doi:10.1097/WON.0b013e318220b6ec
15. Centers for Medicare and Medicaid Services. Appendix PP - guidance to surveyors for long term care facilities. In: *State Operations Manual*. Revised November 22, 2017.
16. Lyder CH, Ayello EA. Pressure ulcers: a patient safety issue. In: Hughes RG, ed. *Patient Safety and Quality: An Evidence-Based Handbook for Nurses*. **Agency for Healthcare Research and Quality:** 2008.
17. Lynn MR. Determination and quantification of content validity. *Nurs Res*. 1986;36(6):382–385.
18. Thorn DW, Deitz JC. Examining content validity through the use of content experts. *OTJR-Occup Part Health*. 1989;9(6):334–346.
19. Pickham D, Ballew B, Ebong K, Shinn J, Lough ME, Mayer B. Evaluating optimal patient-turning procedures for reducing hospital-acquired pressure ulcers (LS-HAPU): study protocol for a randomized controlled trial. *Trials*. 2016;17:190. doi:10.1186/s13063-016-1313-5
20. Jocelyn Chew H-S, Thiara E, Lopez V,

Shorey S. Turning frequency in adult bedridden patients to prevent hospital-acquired pressure ulcer: a scoping review. *Int Wound J*. 2018;15(2):225–236. doi:10.1111/iwj.12855

21. Manzano F, Colmenero M, Pérez-Pérez AM, et al. Comparison of two repositioning schedules for the prevention of pressure ulcers in patients on mechanical ventilation with alternating pressure air mattresses. *Intensive Care Med*. 2014;40(11):1679–1687. doi:10.1007/s00134-014-3424-3
22. Gillespie BM, Chaboyer WP, McInnes E, Kent B, Whitty JA, Thalib L. Repositioning for pressure ulcer prevention in adults. *Cochrane Database Syst Rev*. 2014(4):CD009958. doi:10.1002/14651858.CD009958.pub2
23. National Pressure Ulcer Advisory Panel, European Pressure Ulcer Advisory Panel and Pan Pacific Pressure Injury Alliance. *Prevention and Treatment of Pressure Ulcers: Clinical Practice Guideline*. Haesler E, ed. Cambridge Media; 2014.
24. Anrys C Van Tiggelen H, Verhaeghe S, Van Hecke A, Beeckman D. Independent risk factors for pressure ulcer development in a high-risk nursing home population receiving evidence-based pressure ulcer prevention: results from a study in 26 nursing homes in Belgium. *Int Wound J*. 2019;16(2):325–333. doi:10.1111/iwj.13032
25. Kwong E-W, Pan SM, Aboo GH, Law SS. Pressure ulcer development in older residents in nursing homes: influencing factors. *J Adv Nurs*. 2009;65(12):2608–2620. doi:10.1111/j.1365-2648.2009.05117.x
26. Berlowitz DR, Wilking SV. Risk factors for pressure sores. A comparison of cross-sectional and cohort-derived data. *J Am Geriatr Soc*. 1989;37(11):1043–1050. doi:10.1111/j.1532-5415.1989.tb06918.x
27. Fogerty MD Abumrad NN, Nanney L, Arbogast PG, Poulose B, Barbul A. Risk factors for pressure ulcers in acute care hospitals. *Wound Repair Regen*. 2008;16(1):11–18. doi:10.1111/j.1524-475X.2007.00327.x
28. Ahn H, Cowan L, Garvan C, Lyon D, Stechmiller J. Risk factors for pressure ulcers including suspected deep tissue injury in nursing home facility residents: analysis of national Minimum Data Set 3.0. *Adv Skin Wound Care*. 2016;29(4):1878–1890. doi:10.1097/01.ASW.0000481115.78879.63
29. Pieper B, National Pressure Ulcer Advisory Panel. Pressure Ulcers: Prevalence, Incidence, and Implications for the Future. NPUAP; 2012.
30. Sen CK, Gordillo GM, Roy S, et al. Human skin wounds: a major and snowballing threat to public health and the economy. *Wound Repair Regen*. 2009;17(6):763–771. doi:10.1111/j.1524-475X.2009.00543.x
31. Bergstrom N, Braden B. A prospective study of pressure sore risk among institutionalized elderly. *J Am Geriatr Soc*. 1992;40(8):747–758. doi:10.1111/j.1532-5415.1992.tb01845.x
32. Brandeis GH, Ooi WL, Hossain M, Morris JN, Lipsitz LA. A longitudinal study of risk factors associated with the formation of pressure ulcers in nursing homes. *J Am Geriatr Soc*. 1994;42(4):388–393. doi:10.1111/j.1532-5415.1994.tb07486.x
33. Edsberg LE, Black JM, Goldberg M, McNichol L, Moore L, Sieggreen M. Revised National Pressure Ulcer Advisory Panel Pressure Injury Staging System: Revised Pressure Injury Staging System. *J Wound Ostomy Continence Nurs*. 2016;43(6):585–597. doi:10.1097/WON.0000000000000281
34. Hall KD, Clark RC. A prospective, descriptive, quality improvement study to investigate the impact of a turn-and-position device on the incidence of hospital-acquired sacral pressure ulcers and nursing staff time needed for repositioning patients. *Ostomy Wound Manage*. 2016;62(11):40–44.
35. Bates-Jensen BM, Cadogan M, Osterweil D, et al. The minimum data set pressure ulcer indicator: does it reflect differences in care processes related to pressure ulcer prevention and treatment in nursing homes? *J Am Geriatr Soc*. 2003;51(9):1203–1212. doi:10.1046/j.1532-5415.2003.51403.x