A Retrospective Comparison of Clinical Outcomes and Medicare Expenditures in Skilled Nursing Facility Residents with Chronic Wounds

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Abstract

Medicare skilled nursing facility (SNF) residents with chronic wounds require more resources and have relatively high health-care expenditures compared to Medicare patients without wounds. A retrospective cohort study was conducted using 2006 Medicare Chronic Condition Warehouse claims data for SNF, inpatient, outpatient hospital, and physician supplier settings along with 2006 Long-Term Care Minimum Data Set (MDS) information to compare Medicare expenditures between two groups of SNF residents with a diagnosis of pressure, venous, ischemic, or diabetic ulcers whose wounds healed during the 10-month study period. The study group (n = 372) was managed using a structured, comprehensive wound management protocol provided by an external wound management team. The matched comparison group consisted of 311 SNF residents who did not receive care from the wound management team. Regression analyses indicate that after controlling for resident comorbidities and wound severity, study group residents experienced lower rates of wound-related hospitalization per day (0.08% versus 0.21%, P <0.01) and shorter wound episodes (94 days versus 115 days, P <0.01) than comparison group patients. Total Medicare costs were $21,449.64 for the study group and $40,678.83 for the comparison group (P <0.01) or $229.07 versus $354.26 ($P$ <0.01) per resident episode day. Additional studies including wounds that do not heal are warranted. Increasing the number of SNF residents receiving the care described in this study could lead to significant Medicare cost savings. Incorporating wound clinical outcomes into a pay-for-performance measures for SNFs could increase broader SNF adoption of comprehensive wound care programs to treat chronic wounds.

Key Words: Medicare, long-term care, wounds, injury, cost

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Key Points

- The prevalence, incidence, and costs of care for skilled nursing facility (SNF) residents with chronic wounds are high.
- A retrospective analysis of healed wounds using Medicare and MDS data showed that wound-related costs were significantly lower in residents whose wounds were managed using a standardized, multidisciplinary protocol of care.
- SNF residents who did not receive the consults and protocol of care were more likely to be hospitalized and their wounds took longer to heal.

Healthcare reform has long been debated with emphasis on big picture aspects such as population coverage, insurance market structures with or without a public plan, system finance, provider payment systems, and benefit designs. Evidence-based clinical guidelines, quality measurements, and pay-for-performance have become important parts of the discussion in the move toward healthcare reform implementation. Ultimately, healthcare reform can succeed only if care delivery is rationalized and costs are controlled, which will require the identification of cost-effective systems of care for common chronic conditions.

This study focuses on the treatment of Medicare beneficiary lower extremity chronic wounds managed in the Medicare skilled nursing facility (SNF) setting. Lower extremity ulcers, including pressure, venous, ischemic, and diabetic ulcers, are a common and costly problem in all institutional healthcare settings.[1] Pressure ulcer prevalence may range from 2.2% to 23.9% in the SNF setting and is particularly problematic for older Medicare SNF residents.[2,3] In 2004, of 1.5 million US nursing home residents, approximately 159,000 (11%) had pressure ulcers (any stage) — Stage II ulcers were the most common (5% of residents) and account for 50% of all pressure ulcers.[4] Results of a retrospective cohort study[5] from 2000 showed that venous ulcer prevalence in long-term care settings at admission is 2.5%, with an incidence for patients admitted without a venous ulcer ranging from 1.0% to 2.2% within 90 to 365 days from admission.

With the availability of wound care guidelines for treating and preventing chronic wounds (including pressure, venous, and diabetic ulcers),[6-9] the Centers for Medicare and Medicaid Services (CMS) has included wound care as a quality measure for nursing homes. In the SNF environment, the Design for Nursing Home Compare Five-Star Quality Rating System: Technical User Guide[10] (the Guide) includes the "percent of high risk residents who have pressure sores" as one of its five long-stay quality measures. The Guide indicates that pressure ulcer prevalence can be influenced by nursing home care practices such as, "frequent scheduling of assessments for suspicious skin areas, observations on the environmental assessments of residents, and care practices related to how the nursing home manages clinical, psychosocial, and nutritional complications."[10] Like many aspects of healthcare, much of successful wound care is based on basic clinical principles.[11]

Additionally, several state quality improvement organizations (QIOs) have developed initiatives to prevent and treat pressure ulcers and other chronic ulcers. For example, the New Jersey Hospital Association created a Pressure Ulcer Collaboration that used evidence-based guidelines to develop standards of quality care for pressure ulcers across all provider settings. In this initiative, SNFs represented 21% of the participating organizations.[12] A Texas QIO also was able to improve quality of care and prevent pressure ulcers in SNFs.[13]

In order to heal an ulcer as fast and cost-efficiently as possible, providers at long-term care facilities often use a multidisciplinary approach, including nursing, physical therapy, dietary, pharmacy, and occupational therapy.[14] A pseudo-randomized pragmatic cluster trial[15] conducted in 2007 to determine the effectiveness of providing multidisciplinary wound management using standard modern wound care protocols concluded that treatment of chronic wounds in nursing homes by trained multidisciplinary wound care teams using modern wound care protocols is cost-effective compared to "usual" wound care, which is classified as care provided by healthcare professionals without wound care training and without pharmacist involvement in wound management. Furthermore, the Association for the Advancement of Wound Care[16] (AAWC) notes that the "importance of communicating through an interdisciplinary approach is crucial to ensure that patients are receiving care that is timely and that follows current evidence-based practice." An interdisciplinary approach includes care from a trained wound specialist, a team of healthcare professionals within the SNF, nutritionists, physical therapists, an internal medicine specialist, and family education. As demonstrated in the AAWC Conceptual Framework of Quality Systems for Wound Care,[17] quality wound care is achieved through the six pillars of quality, including safe, effective, patient-centered, efficient, and equitable care.

A risk-based Markov analysis[18] conducted in 2004 to simulate the health and economic outcomes of optimal care of the diabetic foot in a hypothetical population of patients with diabetes found that evidence-based chronic foot wound programs that "included intensive glycemic control, regular foot examinations, risk stratification, patient education, clinician education, and multidisciplinary foot care increased life expectancy and reduced the incidence of foot complications" in patients with diabetes. A white paper[19] developed by the National Pressure Ulcer Advancement Panel in 2009 reviewed the scientific evidence on nutrition and hydration for pressure ulcer prevention and treatment and concluded that under-nutrition may decrease the body's ability to fight infection and have a negative effect on pressure ulcer healing. Protein is responsible for the synthesis of enzymes involved in healing.

SNFs can contract with board-certified physicians and wound-care specialists to provide services; Lee and Turnbull[20]

Table 1. Wound-related diagnoses and procedure codes

Wounds included in study	**ICD-9-CM**
Chronic decubitus (pressure) ulcer	707.0 – 707.09
Ulcer of lower limbs, except decubitus	707.1 – 707.19, 707.8 – 707.9
Varicose (venous) ulcer of lower extremities, with inflammation, and with ulcer and inflammation	454.0, 454.1, 454.2
Open wound of foot, toes	892, 893
Unspecified open wounds of lower limbs	894
Wound-related diagnoses/DRGs[a] (unfavorable clinical outcomes)	**ICD-9-CM**
Wound-related infection	684
Gangrene	785.4
Amputation	895 – 897
Wound-related hospitalization (based on presence of wound-related DRG)[b]	**DRG**
Upper limb and toe amputation for circulatory system disorders	114
Skin graft and/or debridement for skin ulcer or cellulitis with or without complications	263 – 264
Skin graft and/or debridement except for skin ulcer or cellulitis with or without complications	265 – 266
Skin ulcers	271
Amputation of lower limb for endocrine, nutritional, and metabolic disorders	285
Skin grafts and wound debridement for endocrine, nutritional and metabolic disorders	287
Wound debridement for injuries	440
Septicemia	416
Wound debridement and graft	217
Wound-related procedures	**CPT/HCPCS**
Wound debridement	
Removal of devitalized tissue from wounds, nonselective or selective	97602, 97597 – 97598
Debridement of infected skin and subcutaneous tissue/muscle	11000 – 11044
Excision for various types of pressure ulcers	15920 – 15999
Amputation	27880 – 27888, 28800 – 28825
Negative pressure wound therapy	97605 – 97606
Hyperbaric oxygen therapy	C1300, 99183

a Diagnoses Related Groups
b Wound-related hospitalization codes are accompanied by additional wound-related procedures to ensure the patient had a wound

suggested that contracting with a physician to perform debridement services is more cost-effective and results in faster healing times than applying chemical debridement agents and other treatments commonly provided by SNFs. Although several guidelines have been developed on how to prevent chronic wounds, a 1997 survey[21] of 155 family physicians found that more than 70% of physicians feel they lack education on proper pressure ulcer management. Additionally, the same study found that physicians attending one or more nursing homes to provide wound care were more likely to feel strongly that it was the physician's role to provide care to patients with pressure ulcers (P <0.01). Given these findings, it is reasonable to expect that a wound care expert and a multidisciplinary team could provide cost-effective wound care with better clinical outcomes.

The purpose of this retrospective cohort study was to compare clinical outcomes and cost of care between SNF residents with chronic wounds receiving a specific structured, comprehensive wound management protocol (study group) to SNF residents in other mutually exclusive facilities who receive a range of wound care treatments (comparison group).

Methods

The study was conducted using Medicare administrative claims data from the Centers of Medicare and Medicaid Services 2006 Medicare Chronic Condition Warehouse (CCW) file for SNF, inpatient, outpatient hospital, and physician supplier settings and from the Long Term Care Minimum Data Set (MDS). Study and comparison group residents were selected based on the presence of ICD-9-CM and CPT/HCPCS codes indicating the presence of pressure, venous, ischemic, or diabetic ulcers and receipt of wound care treatment and procedures while residing in a SNF. Wound healing was not used as a inclusion criteria in this initial data request (see Table 1).

Wound care. The study group's structured, comprehensive wound care protocol comprises treatment by Vohra Wound Management, Miami, FL, and is consistent with modern wound care standards and an interdisciplinary approach to wound care led by a trained wound specialist. A provider's decision to request a consultation from the wound management team for a SNF resident and use of the wound care protocol is thought to be essentially random, thus limiting facility effects. The protocol includes sharp debridement of nonviable tissue at the bedside and early aggressive topical treatment of heavily contaminated or infected wounds to prevent the need for systematic treatments.

Table 2. Dependent and independent variables used in the regression analyses

Dependent variable	Description	Value
Clinical outcomes	Wound infection	Dichotomous variable
	Gangrene	Dichotomous variable
	Amputation	Dichotomous variable
	Hospitalization with wound diagnosis related group (DRG)	Dichotomous variable
Medicare expenditures	Medicare expenditures per episode	Logarithm of Medicare expenditures per episode
Independent variable	**Description**	**Value**
Patient demographics	Age	Continuous variable
	Gender	Dichotomous variable
	Period of treatment	Continuous variable
Type of ulcer	Chronic decubitus ulcer	Dichotomous variable
	Ulcer of the lower leg	Dichotomous variable
	Venous ulcer	Dichotomous variable
	Foot wound	Dichotomous variable
Conditions/comorbidities	Ischemic heart	Dichotomous variable
	Congestive heart failure	Dichotomous variable
	Diabetes	Dichotomous variable
	Atrial fibrillation	Dichotomous variable
	Lower extremity Neuropathy	Dichotomous variable
	Peripheral arterial disease	Dichotomous variable
	Alzheimer's Disease	Dichotomous variable
	Cataract	Dichotomous variable
	Chronic kidney disease	Dichotomous variable
	Chronic obstructive pulmonary disease (COPD)	Dichotomous variable
	Glaucoma	Dichotomous variable
	Depression	Dichotomous variable
	Hip Fracture	Dichotomous variable
	Osteoporosis	Dichotomous variable
	Stroke	Dichotomous variable
	Cancer	Dichotomous variable
	Gangrene in the pre-treatment phase	Dichotomous variable; only for study residents
	Amputation in the pre-treatment phase	Dichotomous variable; only for study residents

Furthermore, under the guidance of the wound care specialist contracted to provide treatment, the SNF team addresses nutrition, appropriate support services and wound offloading, physical therapy, vascular compromise, pain control, diabetes control, and functional expectations. It is unknown if any care provided in the comparison group was performed by a wound care specialist.

Construction of study and comparison group datasets. Medicare administrative claims data were requested from the CMS for a specified cohort of 2,010 Medicare beneficiaries who received the wound protocol in 2006 (study group). The study group was identified based on the provider number of the contracted wound care specialist in the patient claims. The comparison group of wound patients was identified as those who resided in a SNF in 2006 but did not receive the wound protocol (ie, did not have claims from the contracted wound care specialist and did not reside in the same SNF as any of the study group residents). The comparison group was selected and matched to the study group based on age, gender, and state of residence (N = 2,010). This method ensured that patients in both groups were within the same state but not in the same SNF.

Healthcare utilization and cost. Healthcare utilization and cost information for study and comparison group patients was obtained from the following CMS CCW files for 2006: 1) SNF, 2) inpatient hospital, 3) outpatient hospital, and 4) physician supplier. In addition, 2006 MDS assessment data for SNF stays were obtained. Claims were linked across all sites of service to MDS files for each patient in the database. The first MDS assessment collected after SNF admission that contained wound information was used to determine wound severity, recognizing that wound severity at SNF admission may be less severe ("back-staged") than wound severity before receiving care in the SNF. Payments for the wound-related claims (SNF and providers) are based on the Medicare payment rate attached to each claim for every provider, as provided by the linked claims files. Therefore, this study measures payments outside of the SNF Prospective Payment System (PPS) bundled payment amounts (eg, hospital care).

Construction of episode. Only wounds documented in the claims that had a corresponding wound assessment in the MDS were included in this analysis. The MDS is considered a reliable way to measure nursing home patient characteristics[22] and has been used to validate the clinical accuracy of Medicare administrative data.[23] Due to the statistical limitations of using

Table 3. Residents with completed wound episode (>7 days): resident and wound characteristics

Variable	Study group (A)	Comparison group (B)	Percent difference (A-B)/B
Number of residents	372	311	19.6%
Average wound score at first wound assessment[a]	5.8	5.5	6.0%
Demographics			
Mean resident age (years)	80.8	80.9	-0.1%
Percent female	43.0%	40.5%	6.2%
Wound etiology			
Chronic decubitus ulcer	90.3%	87.1%	4%
Ulcer of the lower leg	53.0%	67.5%	-22%[b]
Venous ulcer	7.0%	12.2%	-43%[b]
Foot wound	7.5%	14.8%	-49%[b]
Comorbidities			
Percent diabetic	51.3%	51.1%	0.4%
Percent with Alzheimer's (with or without dementia)	27.4%	24.8%	10.7%
Percent with peripheral arterial disease	28.2%	43.4%	-35.0%[b]
Percent with lower extremity neuropathy	5.4%	8.0%	-33.1%
Percent with depression	47.6%	41.5%	14.7%
Percent with hip fracture	16.1%	12.5%	28.6%
Percent with stroke	29.0%	27.7%	5.0%

*a Wound severity score for each resident was constructed by multiplying the wound stage by the number of wounds, as indicated on the first MDS assessment available during the wound episode that contains wound information. For example, a resident with two ulcers, one classified as Stage I, and one as Stage II, would have a total wound score of three [(1 wound * Stage I) + (1 wound * Stage II) = 3]*

b P <0.01

data without a defined first and last wound-related claim, only wounds that were first documented and healed during the study period (February 1, 2006 through November 30, 2006) were included in the analysis. Wounds with wound-related claims outside of this study period were excluded because total episode costs and outcomes could not be determined without identification of all previous or future treatments and outcomes. Wounds that were managed and did not fully resolve also were excluded. Although time to healing cannot be directly measured using administrative data, this study assumes the wound is healed once wound-related claims no longer appear in the claims. MDS assessment data are not able to identify the exact timing of wound healing, making it difficult to identify the end of the wound episode using this dataset. Patients whose wound-related claims stopped due to patient death were excluded from the analysis because the wound could not be followed to resolution; however, patients who died after the cessation of wound-related claims remained in the study. In addition, only study group and comparison group residents with a total wound episode >7 days were included in the analysis because wounds that heal in <7 days are demonstrably less severe than the chronic wounds that are the focus of this study. Adjustments to the data reflecting the above decisions and definitions reduced the number of residents included in the study from 2,010 to 372 for the study group and from 2,010 to 311 for the comparison group.

Given the resultant data set, wound care episodes were created for study and comparison group patients. The period from the first wound-related claim through the last wound-related claim is referred to as the *total wound episode* for the study and comparison groups; this definition serves as the basis for examining differences between study and comparison group wound patients. Within the total episode for the study group patients only, wound care treatment and prevalence of unfavorable clinical outcomes due to the study protocol are isolated by creating two components of the total wound episode. The first component is the care provided, as well as resulting unfavorable clinical outcomes, between the first wound-related claim and the first 21 days of receiving care from a study protocol provider (*Before Protocol Episode*). This first 21 days of the protocol treatment are included in this segment because patients often enter the protocol with pre-existing unfavorable clinical outcomes as a result of their previous care. Even though the study protocol is administered at this time, the pre-existing unfavorable clinical outcomes that occur are likely a result of their previous care. The second component is the care provided after the first 21 days of care from the study protocol provider through the last wound-related diagnosis or procedure code (*During Protocol Episode*). These components of the total episode for the study group facilitate comparison of outcomes between the During Protocol and Before Protocol time periods during a wound episode. The comparison group patients are analyzed at the total wound episode level only because they never received the study wound care protocol.

In order to conduct a regression analysis to determine changes in the prevalence of unfavorable clinical outcomes due to the study protocol (excluding unfavorable clinical outcomes present before receiving the study protocol), study group resident data were further differentiated into when they were first treated by the structured protocol (*initial residents*) and after they received care under the protocol for one month (*established residents*). The initial portion includes clinical out-

Table 4. Residents with completed wound episode (>7 days): clinical outcomes

Clinical outcomes	Study group: total wound episode	Study group: during protocol episode[a]	Study group: before protocol episode[b]	Comparison group	Odds ratio: study group total episode to comparison group
Wound infection (%)	0.38%	0.27%	2.13%	0.39%	0.969
Gangrene (%)	0.09%	0.06%	0.37%	0.13%	0.625
Amputation (%)	0.07%	0.04%	0.32%	0.06%	1.165
Wound-related hospitalization (%)	0.08%	0.07%	0.66%	0.21%	0.245[c]

a Clinical outcomes during protocol episode are those associated with care during the structured comprehensive protocol (after first 21 days of first study group provider encounter)
b Clinical outcomes before the protocol episode are all outcomes starting from the first wound claim through the first 21 days of the protocol episode
c P <0.01

Table 5. Residents with completed wound episode (>7 days): clinical outcomes odds ratios

	"Initial" study group protocol residents[a]		"Established" study group protocol residents[b]	
Clinical outcomes	Odds ratio	*P* value	Odds ratio	*P* value
Wound infection (yes, no)	1.146	0.34	0.781	0.03
Gangrene (yes, no)	1.639	0.07	1.337	0.19
Amputation (yes, no)	1.381	0.36	1.549	0.12
Wound-related hospitalization (yes, no)	1.852	<0.001	1.067	0.71

a Clinical outcomes present at the onset of the comprehensive protocol
b Clinical outcomes present after study group residents received care under the comprehensive protocol

comes present at the onset of the comprehensive protocol. Clinical outcomes for established study group residents are compared to the overall comparison group wound episodes. The rationale for this determination is that the protocol cannot influence patient outcomes until it is applied.

Construction of dependent variables. Clinical outcomes for this analysis included wound-related infection, gangrene, amputation, and wound-related hospitalization (determined by the presence of specified ICD-9-CM and CPT codes on physician and hospital claims). Medicare expenditures were separately calculated for Part A, Part B, and wound-related hospitalization. Medicare Part A costs include inpatient hospitalizations and SNF care received. Medicare Part B costs include physician services received during or before a patient's SNF stay, hospital outpatient services, and any Medicare-covered service received after a patient exhausts his/her annual long-term care limit (100 days).

Clinical outcomes are calculated on a per-day basis in order to make them comparable across groups with varying lengths of stay.

Construction of independent variables. Aside from wound care provision, the independent (explanatory) variables included resident demographics, comorbidities, a wound severity score, and a time trend. Resident demographics on which the study and comparison groups were matched included age, gender, and state of residence.

A wound severity score for each resident, regardless of wound etiology, was constructed by multiplying the wound stage by the number of wounds, which are both indicated on the first MDS assessment available during the wound episode that contains wound information. For example, a resident with two ulcers, one Stage I and one Stage II, would have a total wound score of three [(one wound * Stage I) + (one wound * Stage II) = 3]. This approach allows use of Medicare administrative claims data to "adjust" for wound severity across the study and comparison groups because clinical data and medical records are not available to the study team for these patients. However, a study that tested the reliability of the MDS in 13 nursing homes in five states concluded that the information contained in the MDS assessments is reliable for such research.[22]

Statistical analysis. Dependent variables were cross-tabulated against age, gender, diagnosis (comorbidities), type of wound, and wound care treatments. *T*-tests, chi-square tests, and analysis of variance tests were used to determine the statistical significance of the differences between the study and comparison groups (correcting for multiple comparisons). *T*-tests were used to test for the differences in patient demographics, while chi-square tests were used to test for the difference in prevalence of clinical conditions and comorbidities.

Data for the entire episode of the study group were compared to the comparison group in the statistical analysis of clinical outcomes and expenditures. The results of the analysis are presented as the probability of a resident experiencing an unfavorable clinical outcome per day.

Multivariate techniques were used to control for differences in patient demographics and comorbidities and the effect of wound severity on patient outcomes and Medicare expendi-

Table 6. Residents with completed wound episode (>7 days): healthcare costs

Variable	Study group (total episode)	Comparison group	Percent difference	Parameter estimates: study group total episode to comparison group
Medicare Part A payments (including hospital inpatient, and skilled nursing facilities)	$26,568.58	$32,020.59	-17.0%	-0.191[b]
Medicare Part B payments (including hospital outpatient, physician carrier and home health[a])	$7,270.91	$8,658.74	-16.0%	-0.175[c]
Inpatient Medicare payment for wound-related hospitalizations	$27,783.70	$24,969.86	11.3%	0.107
Total Medicare Part A and Part B payment	$21,449.64	$40,678.83	-47.3%	-0.640[b]
Average total Medicare payment for outpatient and inpatient services per day	$229.07	$354.26	-35.3%	-0.436[b]
Average number of days in wound episode	94	115	-18.5%	-0.205[b]

a Home health services are billed under Medicare Part A and Part B. For the purposes of this analysis, all home health services are classified as Part B. Home health payments represent services provided to patients during interrupted stay from the skilled nursing facility
b $P < 0.01$
c $P < 0.05$

tures. Multivariate regressions were used to test the hypothesis that wound protocol residents have better clinical outcomes and lower Medicare expenditures than comparison group residents, after controlling for resident demographics, comorbidities, and wound severity.

Two types of regression models were used. For the dichotomous clinical outcomes (ie, presence of wound infection, gangrene, amputation, and wound-related hospitalization), logistic regression models were estimated. These regressions assess the association between the dichotomous outcome variable and the study treatment protocol after controlling for explanatory variables including time trend and wound severity (see Table 2). The resultant odds ratios indicate the degree to which study group wound patients (residents) have higher or lower odds of unfavorable outcomes than comparison group residents.

For the Medicare expenditure variables, a semi-logarithmic Ordinary Least Squares (OLS) regression specification was used. The dependent expenditure outcome variables are logged and the independent variables are in natural (unlogged) form. The study group variable (a zero-one dummy variable) is included to capture the percent increase or decrease in Medicare expenditures associated with being in the study group, while controlling for numerous confounding (explanatory) variables. The Medicare expenditure dependent variables are overall Medicare cost per total episode and Medicare per diem cost per total episode.

Results

Patient characteristics. The study and comparison groups included 372 and 311 participants, respectively. The average age of residents in both groups was similar (study group, 80.8 years; comparison group, 80.9 years). The prevalence of comorbidities and average wound severity score between the study group and comparison group were not statistically different, with the exception of peripheral artery disease (47.0% for comparison group versus 33.8% for study group, $P < 0.01$) (see Table 3).

The distribution of wound etiologies among the study and comparison group members showed some statistically significant differences. Approximately 90% of the study and comparison groups have chronic decubitus ulcers. The presence of lower leg ulcers is the next most prevalent wound type among the study groups. The prevalence of lower leg ulcers is higher in the comparison group than in the study group (67.5% versus 53.0%, respectively; $P < 0.01$). The prevalence of venous ulcers and foot wounds is twice as high in the comparison group than in the study group (14.8% versus 7.5% for venous ulcers; 14.8% versus 7.5% for foot wounds, $P < 0.01$). Although these differences are statistically significant, only a relatively small proportion of patients have foot wounds and venous ulcers (see Table 3).

Clinical outcomes. After controlling for covariates, study group residents had a similar probability of experiencing wound-related infection, gangrene, and amputation per day across the total wound episode but had a significantly lower probability of experiencing wound-related hospitalization ($P < 0.01$) per day compared to the comparison group. The probability of experiencing wound-related infection per day was 0.38% in the study group, compared to 0.39% in the comparison group. The probability of experiencing gangrene per day in the study group was 0.09% (compared to 0.13% in the comparison group) and the probability of experiencing amputation per day in the study group was 0.07%, compared to 0.06% in the comparison group (see Table 4).

After accounting for model covariates, established protocol patients were 0.781 times less likely to experience a wound-related infection than residents in the During Protocol episode ($P = 0.03$). Initial protocol patients were more likely to expe-

rience gangrene than comparison group patients (1.639) ($P = 0.07$). Initial protocol patients were also more likely to experience a wound-related hospitalization than the comparison group (1.852) ($P < 0.001$) (see Table 5). However, the probability of experiencing a wound-related hospitalization decreased through continued protocol care. Although the odds of a wound-related hospitalization were significantly higher in the initial study period group (1.852, $P < 0.001$), they were lower in the established period (1.067).

Wound-related costs. After adjusting for covariates, study group resident total Medicare Part A and B expenditures for the episode of care were $21,449.64 compared to $40,678.83 for the comparison group, approximately 47% less (see Table 6).

Medicare expenditures for hospitalizations are a large component of total Medicare expenditures. Wound-related hospitalizations for study group residents cost $2,813 more than the matched comparisons during the total wound episode after controlling for numerous covariates ($27,783.70 versus $24,969.86); however, the results are not significantly different statistically. As noted in Table 4, significantly fewer study group residents were admitted to the hospital for a wound-related diagnosis.

Compared to the comparison group, total Medicare Part A payments for the study group protocol were 17% lower ($26,568.58 versus $32,020.59) and total Part B payments were 16% lower ($7,270.91 versus $8,658.74). The predicted values for all study group dependent variables (total Part A, Part B, wound-related hospitalization, and total Medicare expenditures) are calculated independently based on the comparison group costs. As a result, these predicted values do not sum to the total expenditures (Part A and Part B payment) for the study group, but 13% of the Medicare Part B expenditures for the study group were associated with protocol care.

For per diem costs, regression analysis indicates that study group residents incur 35.3% lower total Medicare episode costs per day (per diem) over the entire wound care episode than comparison group residents after controlling for study covariates ($229.07 versus $354.26) (see Table 6). Per diem is the average total Medicare payment (total Part A and B) divided by the average number of days in the wound episode (number of days with wound-related claims). Study group residents' per diem cost for the Before Protocol Episode is approximately $692, compared to $256 during the protocol episode (data not shown).

In addition to lower costs per day, regression results indicate that study group patients have a 21-day (18.5%) shorter length of episode than the comparison group (94 versus 115 days) (see Table 6).

Several independent regression variables are significant in the regression models presented. The likelihood of experiencing unfavorable clinical outcomes in the initial and experienced protocol period is driven by the length of the wound care episode. The presence of a lower limb ulcer increases the likelihood of experiencing an infection, while presence of a venous ulcer increases the likelihood of experiencing a wound-related hospitalization. The age of a patient also affects the likelihood of experiencing gangrene and a wound-related hospitalization. Presence of peripheral arterial disease only affects the likelihood of experiencing gangrene.

Several independent variables influence the cost of total wound care (total Medicare Part A and B costs) as well as the cost per day and overall length of the episode. The explanatory power of the total Medicare costs is driven by the presence of peripheral arterial disease, ischemic heart disease, chronic kidney disease, chronic obstructive pulmonary disease (COPD), and chronic pressure and lower limb ulcers. The explanatory power of the Medicare cost per day is driven by ischemic heart disease, chronic kidney disease, COPD, and cataracts. The length of the total wound episode is a factor of the presence of peripheral arterial disease, osteoporosis, cataracts, and the presence of chronic decubitus, lower limb, or venous ulcers.

Discussion

The clinical outcomes and drivers of wound healing in the current study are generally consistent with the results of previous research. In this study, the only significant difference in comorbidities between residents receiving care from the structured wound protocol specialist (study group) and the comparison group was the increased prevalence of peripheral arterial disease in the comparison group patients. Peripheral arterial disease often is considered the leading cause of lower extremity wounds. A study of the 1999–2000 National Health and Nutrition Evaluation Survey (NHANES) by the National Centers for Health Statistics[24] found that the prevalence of ulcers is three times higher for patients with peripheral arterial disease, peripheral neuropathy, and lower extremity disease. Results of a retrospective cohort study[1] of 397 long-term care residents with pressure, ischemic, venous, neuropathic, and mixed etiology wounds found no effect of peripheral arterial disease on wound healing. Another retrospective review[25] of 400 patients with either pressure, diabetic, or venous ulcers also found no strong relationship between comorbid conditions (such as diabetes, cardiac disease, pulmonary disease, and endocrine disorders) and wound healing. Thus, study results are not likely due to "easier" patient selection. If anything, one would expect the more challenging residents to be included in the study (referral) group. Comparing the probability of unfavorable clinical outcomes per day of study group residents before and after receiving the study group protocol suggests that while the study group resident wounds were not more severe (based on current calculations), the increased probability of experiencing an unfavorable clinical outcome per day suggests that they may not have received optimal care before referral.

After controlling for covariates, patients receiving the study group protocol had a similar probability of experiencing wound-related infection, gangrene, and amputation per day across the total wound episode but a significantly lower probability of experiencing wound-related hospitalization ($P < 0.01$) per day compared to the comparison group.

Receiving the study group protocol over time significantly reduced the odds of having a wound-related hospitalization and reduced the length of episode days from 115 days to 94 days (18.5%) relative to the comparison group. Furthermore, treatment using the structured comprehensive wound management protocol saved Medicare approximately $125 per resident per day of treatment (a 35.3% reduction from the average cost per diem for the comparison group cost of $354). SNF residents who received study protocol care also had lower odds of experiencing a wound-related infection after the protocol care period was established relative to the comparison group. It is well known that the faster wounds heal, the lower the possibility for infection, which can increase treatment cost.[26] Furthermore, faster healing time could facilitate an earlier discharge of the patient from the SNF.

After controlling for resident demographics, comorbidities, and wound severity, the average Medicare savings based on the structured protocol for wounds that healed were $19,229 per episode (an approximately 47.3% reduction from the average cost per episode for the comparison group of $40,678). This is primarily due to reduced hospitalization rates. These results are similar to a recent pseudo-randomized pragmatic cluster trial[15] that assessed the cost-effectiveness of a multidisciplinary team in the nursing home. This study concluded that standardized treatments provided by a trained multidisciplinary wound care team significantly improved healing outcomes and reduced treatment costs. A 2001 clinical perspective analysis[27] confirms that a multidisciplinary wound healing center can improve the clinical outcome of treatments and benefit patients and society.

Prior research has investigated the drivers of wound healing. Specifically, several studies have measured the effect of age on wound healing but none have found a statistically significant correlation between age and wound healing, which is inconsistent with the current finding that age affected the likelihood of experiencing gangrene and wound-related hospitalizations.[1,28,29] Furthermore, studies have found that diabetic and venous ulcers are related to longer wound episodes as well as the number of infections and malnutrition.[28] Presence of peripheral vascular disease and previous stroke have been found to have a significant influence on wound healing, while other cardiac conditions (eg, congestive heart failure, renal insufficiency) were not found to have a significant impact on healing.[1]

During the 12 months from September 2007 through August 2008, the study group protocol was used to treat approximately 16,500 new Medicare SNF residents, an average resident census of approximately 2,600 residents. This is approximately 2% of the national prevalence (159,000 patients)[4] of SNF residents with wounds. The data strongly suggest that incorporating this wound care protocol could lead to significant Medicare savings.

Limitations

Although a study that uses Medicare administrative data has limitations in comparison to randomized controlled trials (RCTs), RCTs have not proven definitive in wound care.[30] To this end, Medicare routinely uses analyses of its statistical system data to inform its decision-making process, especially when the statistical systems contain clinical information such as the SNF MDS, which provides information on the number of wounds and the severity of each wound at a given point in time.[31]

Due to the retrospective design of this study, limitations must be considered. The first limitation is the exclusion of nonhealing wounds or wounds that did not first appear or fully heal between February 1, 2006 and November 30, 2006. Although nonhealing wounds are typically more costly than wounds that heal, conclusions could not be drawn regarding the unfavorable clinical outcomes and episode length and cost without capturing the entire wound episode in the study database in a discrete time period. Also, patients who died during their wound care episode were excluded from the study. Future studies that expand the study window to include wounds that do not heal during the study period would be warranted.

A second limitation to the study is the information available to determine wound severity. By using a retrospective design, the study is dependent on the accuracy, timing, and completeness of the MDS assessments and the demographic information contained in the claims data. Having only the number of wounds by stage for each patient limits the ability to develop a more clinically precise severity measure, which could be used to severity-adjust wounds across patients and track individual wound healing and unfavorable clinical outcomes. However, it is not clear if the availability of this information would produce a measurement bias between the study and comparison groups. Similarly, claims data can be used to make covariate adjustments in a quasi-experimental design framework, but without use of a RCT, the possibility of patient and perhaps facility selection effects on unmeasured variables contaminating the study may exist.

However, it is understood that MDS data collection and reporting requires providers to "back-stage" or "reverse stage" wound severity to show patient wound healing while in the SNF.[32] For example, as a wound heals, the provider will track the wound staging from Stage II to Stage I. Although back-staging is not an acceptable practice within the clinical community,[33] back-staging in the MDS allows the study team to quantify the severity of the wound when the study protocol or comparison group treatment commences, as opposed to the maximum severity of the wound when treated in other settings.

Finally, information about the comparison group treatments is limited. Although it is known that comparison group patients received care in SNFs that were mutually exclusive to those of study group patients, the exact levels of wound care received cannot be known. Comparison group facility characteristics such as staff ratios, tenure and certification of staff members, and availability of specialists including physical therapists and nutritionists is not known and cannot be compared to the characteristics of the study group facilities. Be-

cause study group patients received care from the same group of wound specialists, this standard of care was maintained for all study patients. Although the wound protocol used does not differ from existing standards of modern wound care, it emphasizes multidisciplinary care and consistently applied treatment from a certified wound care specialist. Thus, these results should be able to be obtained by a certified wound care provider with a multidisciplinary team in other SNF settings.

Conclusion

A retrospective cohort study demonstrates that an externally led structured comprehensive wound management protocol results in equal, if not improved, clinical outcomes at significantly lower cost. To this end, strict adherence to comprehensive wound care management is cost-effective. A subsequent study could be conducted to determine if the study group protocol is cost-effective and provides improved clinical outcomes for all wounds and not just wounds that heal.

The study findings have implications for private and public payors such as the CMS. Sufficient payment to wound management specialists will likely encourage the provision of these services to more SNF residents. One approach might be to fund demonstration projects that expand this innovative model of care to additional long-term care facilities. Moreover, the use of value-based purchasing for long-term care that addresses pressure ulcers as a core condition may incentivize facilities to more broadly use comprehensive wound care programs to treat chronic wounds.

The CMS plans to base several pay-for-performance (P4P) measures on the following: 1) potentially avoidable hospitalization, 2) medical outcomes, 3) survey deficiencies, and 4) nursing staffing. The SNF P4P initiative could be funded in part by the savings from fewer wound-related hospitalizations and reduced wound care expenditures associated with structured wound care.[34]

Given the findings of this study, similar studies should be conducted across a variety of healthcare settings. A next logical setting would be home care because wound healing and inappropriate hospitalization in this setting have recently emerged as major quality issues. The CMS recently addressed this issue with two new quality assurance measures for home care: 1) emergent care for wound infections and 2) improving or deteriorating status of wounds,[35] potentially creating opportunities for improved outcomes and cost savings for home-bound patients. ■

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