ORIGINAL ARTICLE

The effectiveness of advanced practice registered nurses with wound care specialization in the home setting on wound resolution and healthcare utilization

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ABSTRACT

Objective: The purpose of this study was to evaluate the effectiveness of advanced practice registered nurses (APRNs) with wound specialization on wound resolution and healthcare (HC) utilization for home health patients.
Methods: A quasi-experimental design with a convenience sample of 30 participants admitted to home health (HH) services compared to a retrospective chart review of 46 participants matched in terms of volume, wound type, wound size, gender, and age was used during the study. The APRN conducted a physical exam and history, obtained wound photography, developed a treatment plan, performed therapy, wrote orders for products and services, and provided a minimum of weekly follow-up visits. Healthcare utilization comprised time for healing, admits to a higher level of care, and amputations. Wound resolution was observed at 80% and 100% closure.
Results: The Intervention and Control Groups were comparable in terms of gender, wound type, age, and acuity, were similar regarding wounds per patient. Both groups achieved 80% volume, 80% area, and 100% wound resolution, regardless of wound types. The Intervention Group's days to wound resolution was statistically significant for fewer days than the Control Group. This difference persisted after analysis of wound types within the groups. The Intervention Group had fewer acute care admits (10%) compared to the Control Group (50%), and the number of amputations was higher in the Control Group, with six amputations compared to only one in the Intervention Group.
Conclusions: Using APRNs with wound specialization improved patient outcomes, efficiency, and costs. The program should be evaluated for adoption and expansion. Further research into the impact of wound-specialized APRNs in the home setting is recommended.

Key Words: APRN, Wound specialization, Wound care, Home health

1. INTRODUCTION

The skin is the largest organ of the human body and is the most susceptible to disease and affliction. Chronic wounds have been defined as those that have not healed spontaneously within four to six weeks. These chronic wounds are typically classified as vascular ulcers (venous and arterial), diabetic ulcers, or pressure injuries (PIs).[1] Chronic leg ulcers have stalled healing after two months of treatment and are usually

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not healed for up to 12 months.

The costs of chronic wounds have steadily grown over the years, shifting from inpatient to outpatient settings.[2] Authors agree that aggressive strategies are needed to prevent and treat chronic wounds in less expensive settings such as the home.[2–5]

Chronic wound care costs between $28.1 billion to $96.8 billion in the United States, affecting approximately 8.2 million people.[6] These numbers are steadily growing due to the aging population and the incidence of chronic diseases such as diabetes, obesity, and peripheral vascular disease.[5,6] Prescription expenditures have doubled with cost shifting to outpatient services related to pharmaceuticals, clinics, and home health visits.[2] More than 12 million people across America are receiving home health care services for various reasons, including the treatment of chronic wounds for a cost of $83 billion.[7] The home health care (HHC) costs per wound averaged $1,670.56 annually above the basic cost per patient.[2] Chronic wounds comprise a large percentage of home health care visits each year, totaling more than 72 million patient encounters.[6]

Many patients with wounds are currently being seen and supervised by individuals with no wound care training or understanding of the best wound care evidence. Consequently, wounds do not heal as effectively.[8] Gallagher and Chraplyvy[9] built a case to hire wound specialty nurses by showing a positive impact on direct and indirect patient expenses. By integrating the expertise of wound care certified advanced practice nurses for those who have home health, chronic wounds can be treated using the most advanced knowledge and techniques, thereby decreasing recovery time.

Several researchers have concentrated on the impact of advanced practice registered nurses (APRNs) within the home setting and in transitional models between settings with positive outcomes, but were not specific to wound care.[2,10–18] Coppa[10] found hospitalizations and readmits significantly decreased where APRNs did autonomous primary care delivery for 82 homebound patients. In contrast, Jones et al.[11] used primary care co-management between the Medical Doctor (MD) and the APRN for 87 HH patients. The APRN made recommendations to the MD and utilized protocols for care delivery. Thirty percent of the patients in Jones' study had chronic wounds with hospitalizations, and 30-day readmits decreased significantly. Both of these studies demonstrated patient outcome improvement regardless of MD oversight.

Rantz[13] researched the impact of APRNs in a nursing home setting on quality measures, including PIs. The APRNs developed evidence-based protocols, conducted staff education, provided direct patient care, and facilitated the transition to the home setting. Similarly, Gonzalez et al.[17] found improved sacral pressure wound healing rates comparing APRNs and primary care physicians using retrospective chart reviews. The incidence and resolution of PIs dramatically decreased in 16 nursing homes using APRNs versus 27 settings using traditional care.

Larsen and Zeni[12] were the only researchers that specifically addressed the impact of an APRN with wound specialization in the home setting. APRN WOCNs delivered home visits in a Mobile Wound Provider Program in Ohio. The APRNs used prescriptive authority to manage 25 patients with chronic wounds over a 90-day period. Fifty-six percent of the wounds reached 100% resolution within this time frame. Wound measurements significantly decreased. Costs were significantly reduced. The program has continued to expand.

Unfortunately, a gap in the evidence exists concerning the utilization of wound-certified APRNs in the home setting. An APRN's advantage is the ability to order products, perform specific treatments such as conservative debridement with sharp instruments, develop a treatment plan for other healthcare providers, teach the patient/support system proper wound care management, and evaluate the outcomes.[18] By having the wound-certified APRN in the home setting, multiple steps of obtaining orders and waiting for products can be eliminated, resulting in more efficient care management and faster wound healing rates.

The project purpose was to evaluate the effectiveness of advanced practice registered nurses (APRNs) with wound specialization in the home setting on wound resolution and healthcare utilization. Wound resolution was observed at 80% and 100% closure. Healthcare utilization comprised time for healing, admits to a higher level of care, and amputations.

2. METHODS

2.1 Study design

This study investigated the benefits of wound care certified APRNs within the home health setting versus traditional home health services currently provided by registered nurses, licensed practical nurses, and unlicensed personnel using a quasi-experimental design. The participants were a convenience sample admitted to home health (HH) services under the Medicare Advantage Plan within a pre-determined geographical area compared to a matched retrospective group of similar participants.

2.2 Sample

The sample comprised 30 Medicare Advantage Plan patients utilizing home health services currently and 46 retrospective patients matched to the Intervention Group in terms of volume, wound type, wound size, gender, and age. Power analysis indicated that a sample size of 70 was needed for significance. The final patient sample size was 30 in the Intervention Group and 46 in the Control Group. A statistically significant difference was determined in these for admits and complications, suggesting a large effect size for the intervention. The wound sample size of the Intervention Group was 93 wounds versus 86 wounds in the Control Group.

The Medicare Advantage HH Liaison notified the study physician of potential participants for the Intervention Group. The study physician/APRN reviewed the potential case for inclusion criteria and consulted with the primary care provider (PCP). Inclusion criteria consisted of Medicare beneficiaries within the Medicare Advantage Plan, typically over 65 years of age, homebound, and presence of a chronic wound. The wound types included diabetic foot ulcer (DFU), venous leg ulcer (VLU), PI, and/or non-healing surgical wound (NHSW). The wound size had to be at least 2.5 cm^2. The exclusion criteria included individuals with cancer, HIV/AIDs, chronic steroid usage, end-of-life care (hospice), palliative wound care, not proficient in English or Spanish, living outside the geographical area, wound size less than 2.5 cm, or patient of a Medicare Risk Providers or Preferred Provider Organization (PPO) members as the payment were not covered. Although there were none, patients who were pregnant, attempting to become pregnant or breastfeeding were excluded from the study due to products which were deemed investigational.

2.3 Ethical considerations

The study received approval from the Protected Health Information and Vendor Ethics Committee and MedCentris management. The designated APRN made a home visit, explained the study, and obtained informed consent. The confidentiality of records identifying the patients was maintained per the MedCentris Confidentiality-Non-Disclosure Agreement.

2.4 Intervention

The Medicare HH Liaison obtained data from a comparable group of homebound patients with chronic wounds outside the designated treatment area. The Control Group was stratified concerning wound type, size, age, gender, and comorbidities to match the Intervention Group as closely as possible. The HH Liaison reviewed the cases to ensure wound care certified APRNs had not conducted a HH visit. The Control Group included any participants who did not receive care or treatment for their wounds from any employed or contracted APRN or one being cared for by a certified wound specialist.

The Intervention Group, consisted of patients cared for by MedCentris providers who interfaced with the patient and the home health agency. Once the referral was received by MedCentris, the Primary Investigator or designated APRN made a home visit. After obtaining informed consent, the APRN conducted a physical exam and history, obtained wound photography, developed a treatment plan, performed therapy, and wrote orders as needed for products and/or services. The APRN updated the HH care plan and the MedCentris electronic medical record (EMR). The APR performed such therapies as excisional debridement, selective debridement, amniotic skin substitutes, autologous platelet-rich plasma graft, negative pressure wound therapy, and advanced wound dressings, such as collagen derivatives and alginates. The APRN ordered pressure offloading mattresses, biosynthetic skin substitutes, total contact casting, compression wraps, nutritional evaluations, and vascular screenings. These procedures and products are FDA-approved and within the APRN scope of practice within Louisiana.

The APRN conducted a minimum of weekly follow-up visits as needed. The MedCentris services were capitated for 30 days. On day 25, the case was reviewed with the study physician and Medicare HH Liaison to justify recertification for the continuation of services based on wound healing status and discharge criteria. Discharge from the Intervention Group occurred when the wound had reached 80% volume contraction or if complete epithelization had occurred, or the member moved out of the geographical area, changed coverage, or elected to disenroll from the study. Upon discharge, the APRN conducted a discharge physical assessment, obtained final colored wound photography, developed a discharge plan, and wrote discharge orders.

Standard Current Procedural Terminology (CPT) coding principles, as determined by the American Medical Association and International Statistical Classification of Disease and Related Health Problems[19] and data sets were utilized to determine the level of acuity, which indicated reimbursement expectations provided by Medicare. Reimbursement was set up on a 30-day global period. The MedCentris provider determined the patient's acuity and assigned CPT codes. Any subsequent visits made during the period were not reimbursed; however, those were captured to indicate that a visit had occurred. All supplies, including dressing materials, sharp instrumentation, and pharmacy items, were included in the MedCentris provider encounter with the patient. The patients were not responsible for any charges incurred during

the MedCentris provider's home visit. MedCentris utilized various vendors for advanced wound healing therapies of which were paid for by MedCentis.

2.5 Outcomes

The primary outcome was wound contraction and resolution calculated by length × width × depth. Wound contraction of 80% or greater was considered wound resolution. Eighty percent was chosen as the wound resolution goal to avoid a possible ethical dilemma of overcharging for wound care that might have occurred with a goal of 100% resolution. At 80% resolution it was assumed therapies prescribed were working and would result in 100% resolution without a potential 30-day recertification needed.

Secondary outcomes included admissions to short-term acute care, long-term acute care, and skilled nursing facility for wound complications such as infection, sepsis, or surgical interventions. Resource utilization was also measured, including HH length of stay, wound care costs, and types of interventions or products.

2.6 Measures

At each patient visit, each wound was measured, including the length, width, and depth at the most extreme margins of the wound. The area was determined by using the length × width. The volume was determined using length × width × depth.

Baseline measurements were obtained upon the first patient visit. The largest area and volume were determined as the largest measurement throughout the patient's treatment study enrollment as noted in the EHR or as documented in the aggregate report for the Control Group.

Eighty (80%) resolution was determined from the largest volume or area measurement. The formula to determine the goal was largest volume minus (largest volume × 0.80) = 80% goal. The date chosen was the visit where the recorded volume was at the goal or less. The 80% area resolution was determined in the same manner.

The percent decreased change was determined by the original number (largest volume) minus the last visit measure equals the decrease, multiplied by 100. The same formula was used for area measurements in place of volume. A negative number denoted an increased change in the percent change, indicating the wound was larger upon the last visit. Zero change indicated no change in the wound size from the largest measurement until the last visit.

Total resolution was the point at which all wound measurements equaled zero, including the length, width, depth, area, and volume.

Days to wound resolution encompassed the days to 80% volume resolution and 80% area resolution. Total resolution was determined using a Date Duration Calculator with days between two dates, including the first and last days. The calculator was available via `timeanddate.com`.

The admissions with the admitting diagnoses and the incidence of amputation were gathered retrospectively from the Medicare Advantage Plan claims data. The Intervention Group data were obtained from a separate Medicare report based on the study participants. The Control Group data were included in aggregate reports.

2.7 Data collection procedures

The intervention data were collected throughout the study period from August 27, 2017, through January 2, 2019. The Control Group data came from an aggregate report supplied by the Medicare HH Liaison on February 15, 2020. Data known to influence healing rates were gathered upon admittance to the study, including age, socioeconomic status, overall health, medical history, co-morbidities, previous wound history, present ulcer history, and medical assessment (i.e., pain, size, duration, site, and the Ankle Brachial Pressure Index assessment). The Intervention Group data collected by the APRN recorded in the EMR included demographics, wound measurements verified by the wound photography, and treatments. The reports were in aggregate with no patient health information.

3. RESULTS

3.1 Sample

The Intervention and Control Groups were comparable. There were no differences in gender, age, wound types, or the number of wounds per patient. The Intervention Group had 30 patients with 93 wounds. The Control Group had 46 patients with 89 wounds. Both groups had a majority of elderly patients with more than one chronic wound.

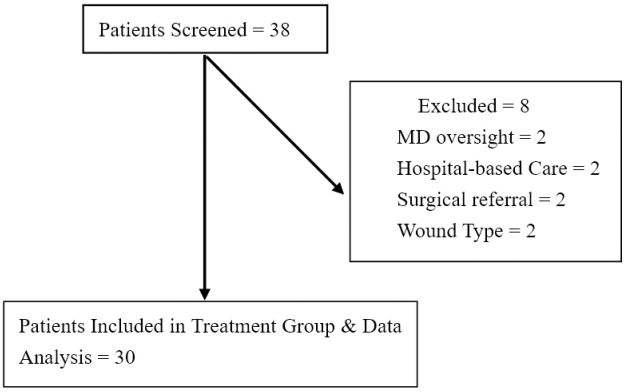

Figure 1. Treatment group patient flow

A designated APRN screened thirty-eight patients. Eight patients were excluded from the study due to the exclusion criteria. Thirty patients met inclusion criteria and signed informed consent. One patient withdrew from the study due to changes in insurance coverage. See Figure 1 for a depiction of the treatment patient flow.

3.2 Demographics

3.2.1 *Gender and wound type*

The Intervention Group had 30 patients with 93 wounds. The Intervention Group was comprised primarily of ambulatory females of approximately 72 years with multiple co-morbidities. The group was most likely to have Diabetes Mellitus Type 2 and Hypertension. The majority had a DFU followed by a PI. The Control Group had 46 patients with 89 wounds and was a majority of males of about 71 years with an average of two wounds per patient. The majority of the group had a DFU followed by a PI. The Intervention Group had an average of 3.1 wounds per patient compared to 1.9 per patient in the Control Group. The ranges were similar in the Intervention Group, with one to seven wounds per patient versus one to eight in the Control Group. The age ranges varied from mid-forties to early nineties in each group. The participants frequently had more than one co-morbidity ranging from none to nine per patient. The majority of subjects (53%) had Diabetes Mellitus Type 2, followed by Hypertension (34%) and Peripheral Vascular Disease (29%). See Table 1 for detailed demographics.

3.2.2 *Gender and wound type comparisons*

Where appropriate, a Chi-square test of Independence, or a two-tailed independent samples *t*-test, was conducted to examine demographic variables based on an alpha value of 0.05. No, statistically significant differences were found. The Intervention and Control Groups were similar in regards to Gender, Wound Types, and Age. See Table 2 for specifics.

Table 1. Demographics

		Intervention Group (n = 30 with 93 wounds)	Control Group (n = 46 with 89 wounds)
Gender	Female	57%	39%
	Male	43%	61%
Wound Type	DFU	34%	42%
	NHSW or VLS	13%	11%
Number of Wounds		1-7 Wounds/Patient	1-8 Wounds/Patient
Age (Mean, years old)		71.7	70.54

Note. DFU = Diabetic Foot Ulcer; NHSW = Non-Health Surgical Wound; VLU = Venous Leg Ulcer

Table 2. Comparison of gender, wound type, and age by group

Variable	Group		χ^2	*df*	*p*
	Intervention	Control			
Gender					
Male	13 [16.18]	28 [24.82]	2.25	1	.134
Female	17 [13.82]	18 [21.18]			
Wound Type					
DFU	32 [35.26]	37 [33.74]	3.13	3	.372
NHSW	12 [11.75]	11 [11.25]			
VLU	19 [14.82]	10 [14.18]			
PI	30 [31.17]	31 [29.83]			
	M/SD	*M/SD*	*t*	*df*	*p*
Age	71.40/12.87	70.54/12.28	0.29	.771	.07

Note. DFU = Diabetic Foot Ulcer; NHSW = Non-Health Surgical Wound; VLU = Venous Leg Ulcer; PI: Pressure Injury; Values formatted as Observed [Expected]; χ^2 = Chi-Square Statistic, N = 76; Degrees of Freedom for the t-statistic = 74; d represents Cohen's d; M = Mean; SD = Standard Deviation; p = level of statistical significance

3.3 Wound characteristics

Comparative analysis was conducted using a two-tailed independent samples *t*-test or Chi-Square to examine the outcome variables of interest within and between the Control and Intervention Groups. The interval and ratio variables included the wound measurements for baseline volume, baseline area, largest volume, largest area, last volume, and last area, along with the percent change in volume and area. The nominal

variables of wound resolution were described, including 80% volume resolution, 80% area resolution, 100% volume resolution, and 100% area resolution. Resolution was determined on the day the measured volume and area met the 80% resolution goal. Eighty percent wound resolution was based on the largest volume and area. Complete (100%) resolution was based on the point when the volume and area measurements reached zero. The percent change in the wound size was based on the largest area and volume compared to the last area and volume measured.

3.4 Comparison of baseline area and volume and largest wound volume/area between groups

The two-tailed independent samples *t*-test was insignificant for baseline wound volume and area measurements. Resolution was based on the largest volume and area, which may or may not have been the baseline measurements. The wounds changed sizes throughout wound management. Therefore, the largest volume and area were used to gauge wound resolution. The result of the two-tailed independent samples t-test was not significant, indicating the largest volume was not significantly different between the Intervention and Control Groups. Similarly, the mean largest area wound measurement between the Intervention and Control Groups was not significant. Therefore, the largest wound volume and area measurements were not significantly different between the two groups (see Table 3).

3.5 Comparison of the percent change between groups

The percent change in the wound volume and area compared the change from the largest volume and area to the last measured volume and area. The two-tailed independent samples *t*-test for the percent change in wound volume and the mean percent change in wound area between the Intervention and Control Groups were insignificant. Essentially, changes in wound size in terms of percent change in wound volume and area were similar between the groups (see Table 3).

Table 3. Baseline area/volume and resolution area / volume by group

Variable	Intervention		Control		*t*	*p*	*d*
	M	*SD*	*M*	*SD*			
Percent Change Volume	65.60	47.73	71.67	106.72	-0.50	.618	0.07
Percent Change Area	79.21	34.42	79.34	42.55	-0.02	.982	0.00
Baseline Volume	11.39	72.05	8.77	23.77	0.33	.745	0.05
Baseline Area	11.75	22.42	11.03	14.86	0.25	.800	0.04
Largest Volume	14.06	73.11	15.94	38.30	-0.22	.829	0.03
Largest Area	14.42	23.78	14.29	17.88	0.04	.965	0.01

Note. N = 182; Degrees of Freedom for the *t*-statistic = 180; *d* represents Cohen's *d*; *M* = Mean; *SD* = Standard Deviation; *p* = level of statistical significance

Table 4. Comparison of wound resolution between groups

	Group		χ^2	*df*	*p*
	Intervention	Control			
80% Volume Resolution					
Yes	66 [70.34]	78 [73.66]	3.04	1	.081
No	19 [14.66]	11 [15.34]			
80% Area Resolution					
Yes	70 [69.49]	66 [66.51]	0.03	1	.863
No	23 [23.51]	23 [22.49]			
100% Resolution					
Yes	53 [49.05]	43 [46.95]	1.37	1	.241
No	40 [43.95]	46 [42.05]			

Note. Values formatted as Observed [Expected]. χ^2 = Chi-Square Statistic used to calculate the *p*-value; *df* = Degrees of Freedom; *p* = level of statistical significance

3.6 Comparison of wound resolution between groups

The Chi-Square of Independence was used to determine the difference in wound resolution between the Intervention and Control Groups. This test was used for 80% volume resolution, 80% area resolution, and 100% or complete resolution between the groups. Wound resolution, including 80% vol-

ume, 80% area, and complete, was not statistically significant between the Intervention and Control Groups. As indicated earlier, an 80% wound resolution goal was chosen to avoid possible over charging for wound care that might have occurred with a goal of 100% resolution. At 80% resolution it was assumed therapies prescribed were working and would result in 100% resolution (see Table 4).

Table 5. 80% volume differences by wound types

Level	Mean Rank	χ^2	*df*	*p*
DFU	55.23	16.14	3	.001
NHSW	91.80			
VLU	73.33			
PI	80.83			

Note. DFU = Diabetic Foot Ulcer; NHSW = None Healing Surgical Wound; VLU = Venous Leg Ulcer; PU = Pressure Injury; χ^2 = Chi-Square Statistic used to calculate the *p*-value; *df* =Degrees of Freedom; *p* = level of statistical significance

3.7 Wound resolution by wound type

A Kruskal-Wallis rank sum test was conducted to assess for significant differences in 80% volume, 80% area, and 100% resolution between wound types. The results were significant, indicating that the mean rank of 80% resolution was significantly different between wound types without consideration of group participation. With 80% area resolution, a statistical difference was noted between wound types. However, upon closer inspection, the exact difference could not be determined. One hundred percent resolution was not statistically significant between the wound types. Thus, there was no statistical difference in wound types between the groups, as noted in the demographics. The only difference in wound resolution by wound type was noted in 80% volume resolution with DFUs. DFUs may heal more quickly than the other types, but a definitive answer was unclear. Essentially, wound type did not seem to influence wound resolution. Table 5 details these statistics.

3.8 Healthcare utilization

3.8.1 *Days to wound resolution*

Healthcare utilization was measured in terms of days to resolution and admits to higher levels of care from the home setting. The days to 80% volume resolution, 80% area resolution, and 100% resolution were counted using the Days Calculator, counting the consecutive days between the first visit and the last recorded visit. The first and last visit days are included in the count. The admit information by patient, diagnosis, and related amputations were provided by the Medicare Advantage Plan. The result of the two-tailed independent samples *t*-test was significant, suggesting the mean of 80% volume days was significantly different between the Intervention and Control Groups.

Additionally, the two-tailed independent samples *t*-test was significant for 80% area resolution days and for days to 100% resolution. The days were shorter in the Intervention Group. Statistics are presented in Table 6.

Table 6. Two-tailed independent samples *t*-test for resolution days by group

Variable	Intervention		Control		*t*	*p*	*d*
	M	*SD*	*M*	*SD*			
80% Volume Days	35.83	40.16	105.25	137.14	-4.30	< .001	0.69
80% Area Days	37.49	36.55	108.82	88.75	-6.06	< .001	1.05
100% Resolution Days	61.94	97.49	118.00	87.59	-2.93	.004	0.60

Note. N = 143; Degrees of Freedom for the *t*-statistic = 95.70; *d* represents Cohen's *d; M* = Mean; *SD* = Standard Deviation; *p* = level of statistical significance

3.8.2 *Days to wound resolution by wound type and group*

A multivariate analysis of variance (MANOVA) was conducted to assess for significant differences in the linear combination of days to 80% volume resolution, days to 80% area resolution, and days to 100% resolution between the groups and wound types. The interaction effect between group and wound type was insignificant, suggesting the linear combination of days to 80% volume resolution, days to 80% area resolution, and days to 100% resolution was similar for each factor level combination of group and wound type. However, the main effect for the group was significant, suggesting the linear combination of days to 80% volume, days to 80% area resolution, and days to 100% resolution was significantly different between the groups. Nevertheless, the main effect for wound type was not significant, suggesting the linear combination of days to 80% volume resolution, days to 80% area resolution, and days to 100% resolution was similar for each wound type. Specific statistics can be seen in Table 7.

To further examine the effects of group and wound type on days to 80% volume, days to 80% area, and days to 100%

resolution, an analysis of variance (ANOVA) was conducted for each dependent variable. The results of the ANOVA were significant for days to 80% volume resolution, while the interaction effect between group and wound type was not significant. The main effect, group, was significant, indicating significant differences in days to 80% volume resolution by group. The main effect, wound type, did not find significant differences of days to 80% volume resolution by wound type. ANOVA examine days to 80% area resolution by group and wound type were significant. The interaction effect between group and wound type was not significant. However, the main effect, group, showed significant differences in days to 80% area resolution by group. The main effect, wound type, was not significant (see Table 8).

Table 7. MANOVA results for days to 80% volume, days to 80% area, and days to 100% resolution by group and wound type

Variable	Pillai	*F*	*df*	Residual *df*	*p*	η_p^2
Group	0.15	4.48	3	74	.006	0.15
Wound Type	0.18	1.62	9	228	.111	0.06
Group &Wound Type	0.16	1.43	9	228	.176	0.05

Note. Pillai = positive valued statistic ranging from 0 to 1.0; The null hypothesis should be rejected for high values; *F* = the ratio of explained variance to error variance; used with 2 *df* values to determine the *p*-value; *df* = Degrees of Freedom; *p* = level of statistical significance; η_p^2= Partial Eta Squared effect size

Table 8. Days to 80% volume resolution by group and wound type

Term	*SS*	*df*	*F*	*p*	η_p^2
80% Volume Resolution					
Group	138,310.32	1	12.07	< .001	0.08
Wound Type	23,783.26	3	0.69	.559	0.02
Group & Wound Type	8,074.39	3	0.23	.872	0.01
Residuals	1.55×10^6	135			
80% Area Resolution					
Group	163,378.47	1	35.98	< .001	0.22
Wound Type	18,128.10	3	1.33	.267	0.03
Group & Wound Type	4,417.46	3	0.32	.808	0.01
Residuals	581,162.54	128			
100% Resolution					
Group	60,217.48	1	7.70	.007	0.08
Wound Type	40,402.37	3	1.72	.168	0.06
Group & Wound Type	63,239.91	3	2.70	.051	0.08
Residuals	688,239.54	88			

Note. SS = Sum of Squares; *F* = the ratio of explained variance to error variance; used with 2 *df* values to determine the *p*-value; *df* = Degrees of Freedom; *p* = level of statistical significance; η_p^2 = Partial Eta Squared effect size

ANOVA to determine significant differences in days to 100% resolution by group and wound type found significant differences in days to 100% resolution days among the group and wound type (see Table 8). The interaction effect between group and wound type was not significant, while the main effect, group, found significant differences in days to 100% resolution by group. The main effect, wound type, was not significant.

3.8.3 *Admits*

Admits to a higher level of care from the home setting were reviewed for the Intervention and Control Groups. Within the Intervention Group, three patients, or 10% of the sample, were admitted. Those three patients had five admit episodes. In the Control Group, 23 patients were admitted, or 50% of the participants. These 23 patients had 47 admit episodes.

The admit episodes counted were directly related to the wound/s. The admit diagnoses were similar between the groups. Some admits had more than one diagnosis, such as osteomyelitis and sepsis. The most frequent admit diagnosis was osteomyelitis, followed by wound infection. In addition to the common diagnoses noted, the Control Group also had one hardware removal, one skin flap closure, and one pelvic

abscess. These diagnoses and/or procedures were related to NHSWs and considered outliers.

3.8.4 *Amputations*

The admit diagnoses and procedures identified amputations performed on participants within both groups. The Intervention Group had one below knee amputation (BKA), while the Control experienced three BKAs, two transmetatarsal amputations, one above knee amputation (AKA), and one toe.

3.9 Summary

The results have demonstrated that the Intervention and Control Groups were comparable in terms of gender, wound type, and age. Patient acuity was similar regarding wounds per patient. The co-morbidities were unknown in relation to the Control Group; however, the assumption was that both groups were elderly high acuity patients with chronic wounds that are homebound.

Both groups achieved 80% volume, 80% area, and 100% wound resolution, regardless of wound types. A significant difference was found in regards to days to 80% volume, 80% area, and 100% wound resolution in the Intervention Group compared to the Control Group. The Intervention Group's days were significantly less than the Control Group in reaching the various levels of wound resolution. This difference persisted even in a more in-depth analysis of wound types within the groups. DFUs reached resolution in advance of VLUs and PIs. However, no significant difference was found between the groups regarding wound types.

An additional significant finding was the number of patients admitted to higher levels of care from the home setting by group. The Intervention Group had fewer admits than the Control Group. The admit diagnoses and the level of care settings were similar. Also, the number of amputations was higher in the Control Group.

4. DISCUSSION

No statistically significant differences were noted between the groups in 80% volume, 80% area, or 100% wound resolution. However, there was a significant difference in the time to wound resolution, with the Intervention Group requiring 33% to 50% fewer days to reach wound resolution than the Control Group. Admissions to a higher level of care were also demonstrated to be significantly less in the Intervention Group, with three patients (10%) accounting for five admit episodes. In contrast, the Control Group had 23 patients (50%) with 47 admit episodes. In addition, the Intervention Group had one amputation compared to seven in the Control Group. The Intervention Group demonstrated a significant decrease in HC utilization. The current study's population also reflected the epidemiology studies that stated the prevalence and incidence of chronic wounds were higher among elderly Medicare beneficiaries, with a majority of DFUs.[2,6] Thus, the study population was representative of the target population.

No statistically significant difference was noted between the groups in 80% volume, 80% area, or 100% resolution, although the sample sizes were adequate. The Control Group had a slightly larger percentage of wounds that reached 80% volume resolution at 88% compared to 71% in the Intervention Group. However, 80% achievement in wound resolution from baseline measurements was used as selection criteria for the Control Group members. Consequently, the results could be skewed. The Intervention Group percentages were slightly higher than the Control Group for 80% area and 100% resolution.

Previous authors reported impressive wound resolution but did not have a comparison group.[12,16] The evidence suggests that there may not be a statistical difference in wound resolution achievement between traditional HH and WOCN wound management. Larsen and Zeni[12] offered the only study that addressed this intervention besides the current one.

A statistical difference in achieving 80% resolution by wound type without consideration of the group was noted. Regardless, there was no variation in wound types between the groups. Therefore, wound types did not seem to influence the achievement of wound resolution. Even though no statistical significance was determined regarding wound resolution, a difference was determined in time to healing between the groups. The Intervention Group had significantly fewer days to 80% volume, 80% area, and 100% resolution than the Control Group. Larsen & Zeni[12] commented on a decreased time to healing with wound specialized APRNs but had no comparison group. The difference in terms of days to wound resolution was impressive between the Intervention and Control Groups. Often the Intervention group's days to resolution were one-third to one half less than those of the Control Group. The control group's maximum time to 80% volume resolution reached 1,118 days or around three years. In truth, VLUs can require up to two years for wound resolution.[5] However, the maximum for the Intervention Group was 261 days or less than one year. The same pattern was illustrated for 80% area and 100% resolution. These dramatic differences demonstrate the value of aggressive wound management as well as the increased autonomy of the APRN in this setting. The autonomy allowed the APRN to order prescriptions, treatments, and DME while decreasing the time for approvals and implementation. The decreased time to healing reflects tremendous cost savings. These cost sav-

ings were attributed to the decrease in healing time, wound protocols, supplies, and DME recommendations.

The literature suggested there was a difference in days to healing by wound type. Paisey et al.[4] stated that DFUs might heal faster than other wound types. Perez et al.[5] stated that VLUs possibly require longer healing times. Multivariate analysis determined that there was no difference in the time to healing by wound type or the interaction of group and wound type for this study. The only statistical difference in days to wound resolution was in relation to the group, confirmed in the post hoc ANOVA results. These findings illustrate that the interventions such as skin substitutes, platelet rich plasma applications, and offloading strategies influenced the decreased healing times in this study, not the wound type.

One of the most astounding findings of the current study was the incidence of admissions to a higher level of care between the Intervention and Control Groups. The Intervention Group had three patients (10%) that accounted for five admit episodes. In contrast, the Control Group had 23 (50%) patients that were admitted. These patients experienced 47 admissions. Most of the admissions were to acute care settings or hospitalizations. These findings support several study results that demonstrated a decrease in hospitalizations due to WOCN and APRN interventions.[10,11,15,16] Again, the difference in admits reflects substantial cost savings.

The decrease in admits also showed a decrease in complications. The admit diagnoses were similar, such as osteomyelitis, wound infection, cellulitis, and gangrene. Also, the wound specialized APRN could deliver advanced modalities in the home, such as sharp debridement, placement of skin substitutes, such as amniotic skin substitutes and platelet rich plasma grafts.

As noted previously, amputations greatly affect the patient's emotional and physical health.[3] The individual's functionality and independence are severely limited afterward. The Intervention Group had one amputation out of 30 patients with 93 wounds. The striking contrast was the seven amputations in the Control Group out of 46 patients with 89 wounds. These amputations represent a huge HC expenditure in direct medical costs and lost productivity. According to Font-Jimenez et al.,[3] the incidence of amputations is declining due to more aggressive wound management and therapies. This difference in amputation rates demonstrates the value of wound management by a wound specialized APRN in the home setting.

4.1 Strengths and limitations

This study's major strength was the support the sponsors and the clinical team gave. Intervention integrity was maintained throughout the study. Oversight was meticulous from the Medicare Advantage Plan and MedCentris. The comparison groups were homogeneous, thus, controlling several confounding variables such as age, gender, and wound type.

The major limitations were the lack of randomization and reliance on retrospective data retrieval. Randomization would have improved the representativeness of the target population. In addition, more demographic and treatment data may have been available. The retrospective data retrieval was dependent on the accuracy of EMR documentation, claims data, and aggregate reports. Specific data regarding the number of HH visits, ED or urgent care visits, and hospitalization days was not readily available. In addition, cost data were also limited.

5. CONCLUSIONS

Further research should be conducted to gather evidence regarding the impact of wound specialized APRNs in the home setting on wound resolution and HC utilization as there remains a large gap in evidence with conflicting findings. Such evidence would support reimbursement models for such APRNs in the home setting. In addition, consideration should be given from a policy and legislative standpoint on APRN practice regarding the home setting, especially in the ability to order and certify home health utilization and orders. Perhaps value-based reimbursement models would stimulate the interest in pursuing the utilization of such APRNs in the home setting with improved outcomes, efficiency, and cost-effectiveness.

Not addressed in this study but of profound importance is the disparity in the extent of wounds and amputations related to geographic residence (rural) and ethnic differences (Black) among patients. Patients in rural areas are more likely to have amputations secondary to unhealed wounds. Those patients who are Black showed a two-fold increase over Whites in terms of experiencing gangrenous wounds. The intersection of these two social determinants of rural and Black is especially impactful, with an 80% increase in major leg amputation or death for Black patients living in rural communities. Additional research to identify the best practices to close the gaps in health disparity for these populations should be prioritized.[20,21] A model such as that employed in this study, where wound-specialized APRNs can deliver timely and extensive interventions in the home setting, could be effective at closing this gap.

APRNS with wound specialization impacted wound healing with reduced days to wound resolution, and fewer admits reflecting fewer complications of wound infection, cellulitis, and sepsis. The Intervention Group also had fewer ampu-

tations. These outcomes illustrate the effectiveness of advanced modalities delivered in the home. Wound specialized APRN utilization in the home setting is an effective use of their expertise with complex chronic wound management.

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CONFLICTS OF INTEREST DISCLOSURE

The authors declare they have no conflicts of interest.

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