Original Investigation

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Improving Wound Healing and Infection Control in Long-term Care with Bacterial Fluorescence Imaging

Martha R. Kelso, RN, CWHS, HBOT and Mark Jaros, PhD

ABSTRACT

BACKGROUND: High bacterial burden stalls wound healing and can quickly progress to infection and sepsis in complex, older-adult patients in long-term care (LTC) or skilled nursing facilities (SNFs).

OBJECTIVE: To investigate the outcomes of point-of-care fluorescence (FL) imaging (MolecuLight i:X) of bacterial loads, which are frequently asymptomatic, to inform customized wound treatment plans for patients in LTC/SNFs.

METHODS: In this retrospective pre/postinterventional cohort study, the authors compared the healing and infection-associated outcomes of 167 pressure injuries from 100 Medicare beneficiaries before and after implementation of FL imaging.

RESULTS: Most patient demographics and wound characteristics did not differ significantly between the standard-of-care (SOC; n = 71 wounds) and FL (n = 96 wounds) cohorts. Significantly more wounds (+71.0%) healed by 12 weeks in the FL cohort (38.5%) versus the SoC cohort (22.5%). Wounds in the FL cohort also healed 27.7% faster (–4.8 weeks), on average, and were 1.4 times more likely to heal per Kaplan-Meier survival analysis (hazard ratio = 1.40; 95% CI, 0.90-2.12). Infection-related complications decreased by 75.3% in the FL cohort, and a significant shift from largely systemic to topical antibiotic prescribing was evidenced.

CONCLUSIONS: Fluorescence-imaging-guided management of wounds significantly improved healing and infection outcomes in highly complex and multimorbid patients in LTC/SNFs. Proactive bacterial infection management via local treatments was enabled by earlier, objective detection. These reported outcome improvements are comparable to randomized controlled trials and cohort studies from less compromised, selectively controlled outpatient populations. Fluorescence imaging supports proactive monitoring and management of planktonic and biofilm-encased bacteria, improving patient care in a complex, real-world setting.

KEYWORDS: autofluorescence imaging, bacteria, biofilm, healing, infection, long-term care, MolecuLight, pressure injury, skilled nursing facilities, wounds

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INTRODUCTION

Chronic wounds represent a silent, global epidemic with substantial implications. Roughly 8.2 million Medicare beneficiaries will experience a chronic wound in their lifetime;[1] this is projected to increase in the coming decades due to an aging population, alongside surging risk factors, such as diabetes, cardiovascular disease, and obesity, among many others.[2–5] Wound infections are particularly devastating in complex patients (eg, older adults, multimorbid, disabled) who are overrepresented in long-term care (LTC) and skilled nursing facilities (SNFs). These infections frequently initiate complications leading to prolonged hospitalization, including amputations, sepsis, and death.[6] This comes at a tremendous human and economic cost. The prevalence of pressure injuries (PIs) in LTC/SNFs ranges from 3% to 54%,[7–9] and estimates of Medicare's annual spending on wound care ranged from $28.1 billion to $96.8 billion in 2018.[10]

Both local and systemic factors contribute to wound chronicity. Local factors include persistent high bacterial loads, biofilm, and bacterial infections.[11–14] Early diagnosis of these local, proinflammatory factors and their proactive intervention may help prevent an array of complications that range from simple infections to skin-originated sepsis, amputations, and death.[15] However, diagnosis is challenging in older or otherwise compromised patients who struggle to mount clinical signs and symptoms of inflammation and/or infection, be it local or systemic.[16] Residents in LTC are sevenfold more likely to develop severe sepsis than age-matched nonresidents.[17] Further, once established, they are twice as likely to require ICU care and/or to die during hospitalization.[17] Inequities in social determinants of health (eg, socioeconomic status, racial background, food insecurity) are all too common in LTC/SNF settings, further

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driving poor outcomes. For example, PIs are more severe and less likely to heal in Black versus White nursing home residents.[18,19]

Although efforts to improve wound outcomes are urgently needed, research initiatives and investments in healthcare technology frequently evade LTC/SNF residents. Point-of-care, noninvasive fluorescence (FL) imaging for wound bacterial loads and locations is a unique technology that improves healing outcomes and overcomes diagnostic challenges associated with blunted immune responses and misinterpretation of clinical signs and symptoms in highly pigmented skin. The handheld imaging device emits a safe violet light under which elevated, healing-inhibitory bacterial loads[20] and tissue components produce detectable FL signals in real time. Clinical trials have validated this technology across a range of wound types[21–25] and skin pigmentations.[26] The imaging procedure prompted treatment plan changes in 50% to 70% of wounds.[21,22,27] With an image-informed approach to bacterial management, randomized controlled trial (RCT) evidence reports a doubling of diabetic foot ulcers (DFUs) healed at 12 weeks.[15] A retrospective cohort study reported a 33% decrease in systemic antibiotic prescribing alongside improvements in 12-week foot ulcer healing rates with FL imaging.[28]

Study Objectives

Given the logistical and ethical complexities of robust prospective studies in LTC/SNFs, real-world retrospective research has a valuable role in determining the impact of novel technologies in this complex population. Although this approach may display lesser scientific rigor compared with highly selective clinical trials, it provides a realistic estimation that can be confidently extrapolated to the LTC/SNF population and other real-world clinical settings.

In this retrospective cohort study, the authors examine the impact of FL imaging on patient-centric outcomes including wound healing, wound infection, and infection-associated complications. They also examine how this procedure modified bacterial infection management strategies and resource utilization, including the use of antibiotics.

METHODS

Study Design

This retrospective, pre/postinterventional cohort study examined patients treated by 18 Wound Care Plus, LLC (WCP) providers across 55 LTC and SNF facilities. Wound Care Plus is an advanced traveling wound care specialty group treating patients across US care facilities. Providers at WPC adopted FL imaging (MolecuLight *i:X*; MolecuLight) in early 2021. This date served as the cutoff to generate the two study cohorts: standard of care (SoC) with no FL imaging and FL.

The handheld FL imaging device emits a violet light under which bacteria at loads greater than 10^4 colony-forming units (CFU)/g (both planktonic and biofilm-encased) produce detectable FL signals in real time, in turn guiding clinical actions.[20,21,23] The providers using FL were certified in FL image capture and interpretation following hands-on training and completion of an online learning module with a score of 80% or better.

Wound Care Plus first treated wounds in the SoC cohort between January 2019 and February 2020 and treated wounds in the FL cohort between May 2021 and March 2022. These timeframes reduced bias from restricted provider access and resource shortages during the height of the COVID-19 pandemic. Primary data collection was completed in July 2022; the follow-up period varied per patient and included data available up to that point.

The study protocol was developed in accordance with the Declaration of Helsinki and was approved by an institutional review board (Veritas, Montreal, Quebec, Canada). Every effort was made to protect patient confidentiality; only WCP staff had access to deidentified information. Each participant provided informed consent. This study is registered on ClinicalTrials.gov with NCT#06068972.

Screening and Inclusion

The study patients/wounds were selected from the centralized WCP patient database using a systematic, randomized screening process. An initial screen identified patients who (1) received at least one debridement as indicated by Current Procedural Terminology (CPT) codes 11042, 11045, 97597, and 97598 during the admission study period (to confirm that the patients were actively being treated); (2) were treated in an LTC or SNF setting; and (3) were covered beneficiaries of Medicare of Missouri. Due to beneficiary volume and applicability to Medicare beneficiaries across the US, the authors focused on Medicare patients. (4) Finally, patients in the FL cohort must have received at least one FL imaging procedure during the study admission period, as indicated by CPT code 0598T. Initial screening yielded 92 SoC and 102 FL cohort patients with an array of wound types.

Next, the authors selected up to three wounds per patient to be included in this study. Eligible wound types included PIs and mixed-etiology ulcers with pressure as a primary contributing factor (considered PIs for the purpose of this study). Wound classifications (types) were collected from the electronic health record (EHR) database and had been assigned by WCP providers per standard institutional protocols (clinical examination, diagnostic tests, pressure screening assessments,

etc). Other wound types commonly treated by WCP were excluded (eg, traumatic wounds; skin tears; moisture-associated skin damage; and diabetic, arterial, and venous leg ulcers). Any patients identified in the first step of the screening process who did not have eligible wound types were excluded at this point.

Next, the authors applied additional inclusion criteria beyond wound type: (1) the wound must have received care by WCP providers for at least 4 weeks; (2) the wound's admission date must have been within the study period (SoC or FL); and (3) for the FL cohort only, the wound must have received at least one FL imaging procedure. When a patient had more than three eligible wounds, a random-number generator selected three wounds only for inclusion. Two patients had wounds eligible for inclusion in both cohorts (eg, one SoC wound and two FL wounds); in both cases, the treatment periods between the SoC and FL wounds did not overlap.

Data Collection and Analysis

The authors developed the primary research questions before abstracting data from the WCP EHR database. The data points to be collected were defined in accordance with extensive literature research on wound healing-related variables and risk factors in LTC/SNFs. A researcher-created data collection manual guided trained data abstractors. Two data audits were performed by an independent analyst to ensure reliability.

Demographics, wound characteristics, and treatment aspects were compared between the cohorts, including number of debridement procedures (conservative sharp, sharp surgical), number of swab and/or tissue microbiologic samples, number of topical and/or systemic antibiotic courses prescribed per wound, and number of FL imaging scans. Researchers also determined the incidence of wound infection (International Wound Infection Institute criteria) and infection-related complications (cellulitis, osteomyelitis, gangrene, sepsis, or a wound-associated hospitalization) based on *International Classification of Diseases, Tenth Revision* codes linked to the wound of interest.

Analysis of Wound Healing

Wound healing was defined as the complete epithelialization of an original ulcer or a surface area of 0 cm^2. Wound healing analysis included (1) average time to heal for SoC versus FL wounds; (2a) Kaplan-Meier survival analysis to compare the probability of healing over time between cohorts; (2b) hazard analysis of the cohort survival curves to determine the likelihood of healing at any given time; and (3) Cox proportional hazards (Cox PH) regression modeling of 12-week healing to account for wound-related variables known to impact chronic wound healing, wound location, and baseline wound area, as identified by Cho et al[29] using EHR data from 261,398 patients across 532 US wound care clinics.[29] The data for Kaplan-Meier analysis survival were censored for patients who were lost to follow-up due to death or discharge or whose wounds were unhealed at the study's end. The data for Cox PH analysis were censored for patients who were lost to follow-up due to death, discharged, or wounds unhealed before 12 weeks. The data for all other analyses were not censored.

Statistical Analysis

Statistical analysis was conducted by an outsourced statistical analyst (Summit Analytical, Denver, Colorado, USA) using SAS version 9.4 (SAS). Categorical data were analyzed using χ^2 or the Fisher exact test. Continuous data were analyzed using the Mann-Whitney U test or t test, as appropriate. Normality was tested using the Shapiro-Wilk test. Differences in the shapes of the Kaplan-Meier survival curves were assessed using the Gehan-Breslow-Wilcoxon test, and Mantel-Haenszel hazard ratio analysis was used to evaluate differences in slope.

RESULTS

Study Population

Patient demographics and wound characteristics are summarized in the Table. A total of 167 PIs from 100 patients were included in the present study: 46 SoC patients (71 wounds) and 56 FL patients (96 wounds). Patients were followed for 14.7 weeks on average and were typically treated by WCP on a weekly basis. Over 90% of the wounds in both cohorts were classified as full thickness. The patients' wound(s) were primarily located in the pelvic region (ischium, buttock, sacrum, hip, coccyx), on the foot (including ankle), or otherwise on the leg. The distributions in wound location differed significantly between the cohorts ($P = .01$), with fewer pelvic wounds in the FL cohort. The mean wound surface area measured at admission was 15.6 ± 22.4 cm^2 for the SoC cohort and 14.3 ± 25.7 cm^2 for the FL cohort. Most patients were multimorbid (average of two comorbidities) and took over five systemic medications regularly (>85%). The number of comorbidities per patient; history of smoking, alcohol, and illicit drug use; and the proportion of patients prescribed systemic antibiotics for non-wound-related reasons were similarly distributed and were not significantly different between the SoC and FL cohorts (Table). However, patients in the FL cohort were significantly older (+8 years, $P = .004$), potentially putting them at a disadvantage in terms of healing potential compared with the younger SoC population.

Wound Healing by 12 weeks

Many of the wounds studied were followed for at least 12 weeks, as shown below the Kaplan-Meier survival

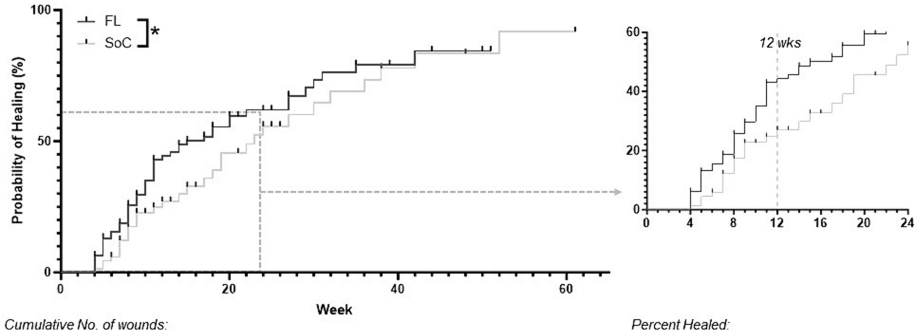
Table. PATIENT AND WOUND CHARACTERISTICS

Variable	SoC Cohort (n = 46), n (%)	FL Cohort (n = 56) n (%)	χ^2	*P*
Patient Characteristics (N = 100 total[a])				
Age, mean (SD), range, y	73.2 (15.4), 41–98	81.5 (10.2), 56–100		.01
Sex			0.81	.37
Female	23 (50.0)	33 (58.9)		
Male	23 (50.0)	23 (41.1)		
Polypharmacy[b]			0.44	.50
Yes	40 (87.0)	51 (91.1)		
No	6 (13.0)	5 (8.9)		
Comorbidities[c]			2.26	.13
None	11 (19.6)	7 (12.5)		
>1	35 (76.1)	49 (87.5)		
No. of comorbidities, mean (SD)	1.76 (1.6)	1.80 (1.5)		.84
Antibiotics for non-wound-related reasons[d]			1.05	.59
Yes	6 (13.0)	9 (16.1)		
No	40 (87.0)	46 (82.1)		
Unknown	—	1 (1.8)		
History of alcohol use			1.98	.37
Yes	1 (2.2)	4 (7.1)		
No	13 (28.3)	19 (33.9)		
Unknown	32 (69.6)	33 (58.9)		
History of smoking			0.99	.61
Yes	11 (23.9)	9 (16.1)		
No	16 (34.8)	21 (37.5)		
Unknown	19 (41.3)	26 (46.4)		
History of illicit drug use			2.16	.34
Yes	1 (2.2)	1 (1.8)		
No	11 (23.9)	21 (37.5)		
Unknown	34 (73.9)	34 (60.7)		
Overall no. of wounds, mean (SD), range[e]	7.7 (12.2), 1–76	7.3 (11.6), 1–86		.98
Wound characteristics (N = 167)				
Wounds	71 (42.5)	96 (57.5)		
Baseline surface area, mean (SD), range, cm^2	15.6 (22.4), 0.2–120	14.1 (25.7), 0.1–169		.52
Wound severity			2.28	.32
Full thickness	67 (94.4)	89 (92.7)		
Partial thickness	1 (1.4)	5 (5.2)		
Unstageable	3 (4.2)	2 (2.1)		
Wound location			11.10	.01
Leg[f]	5 (7.0)	15 (15.6)		
Foot[g]	14 (19.7)	35 (36.5)		
Pelvic[h]	50 (70.4)	45 (46.9)		
Other	2 (2.8)	1 (1.0)		

Abbreviations: FL, fluorescence; SoC, standard of care.
[a]Two patients are in both the SoC and FL cohorts.
[b]Polypharmacy is defined as more than five concurrent systemic medications.
[c]Comorbidities included diabetes, obesity, malnutrition/anemia, chronic obstructive pulmonary disease, congestive heart failure, vascular insufficiency, lymphedema, and immunodeficiency.
[d]During the study period.
[e]Total number of wounds treated by Wound Care Plus over patients' lifetime.
[f]Excluding the foot.
[g]Includes wounds on the ankle.
[h]Includes wounds on the ischium, buttock, sacrum, hip, and coccyx.

Figure 1. STATISTICALLY SIGNIFICANT DIFFERENCES IN THE KAPLAN-MEIER SURVIVAL CURVES FOR THE SoC AND FL COHORTS

The inset highlights the first 24 weeks of follow-up where the FL cohort outperformed SoC, and most participants in both cohorts were lost to follow-up. Vertical black dashes along the curves indicate instances of wounds lost to follow-up (data censoring); jumps in the staircase indicate instances of wound healing.



Cumulative No. of wounds:

Wk	0	4	8	12	18	24	30	36	42	48	54	60
SoC	71	71	51	33	20	14	9	7	4	3	2	1
FL	96	96	70	40	26	16	10	8	4	3	1	1

Percent Healed:

Wk	4	8	12	18	24
SoC	1.4	15.5	22.5	28.2	35.2
FL	6.3	24.0	38.5	45.8	49.0

Abbreviations: FL, fluorescence; SoC, standard of care.

curve (Figure 1). The average duration of wounds that healed at any point during the study was 17.2 ± 12.4 weeks for SoC and 12.4 ± 8.9 weeks for FL (Figure 2), meaning FL-imaged wounds healed 27.7% (−4.8 weeks) faster on average (P = .043). Further, FL imaging was associated with a 71.0% increase in the 12-week wound healing rate (P = .007, Fisher exact test): 38.5% (37/96) of the FL cohort had healed by 12 weeks versus 22.5% (16/71) of the SoC cohort (Figure 1).

There was also a statistically significant difference between the shapes of the Kaplan-Meier survival curves (P = .049), where the FL cohort generally performed better during the first 24 weeks. The rate at which healing occurred over time (slope of the curve) also differed between the SoC and FL cohorts (hazard ratio, 1.40; 95% CI, 0.90-2.12), such that patients in the FL cohort were 1.4 times more likely to experience wound healing at any given time.

When controlling for wound location and baseline wound surface area, per Cox proportional hazards regression, patients in the FL cohort were 1.80 times more likely to heal within 12 weeks as compared with those in the SoC cohort (hazard ratio, 1.80; 95% CI, 0.93–3.48). Although this approached statistical significance (P = .080), in combination with the Kaplan-Meier analysis and based on the spread of the 95% CIs in both analyses, this suggests that wounds having received FL imaging trended toward favorable healing.

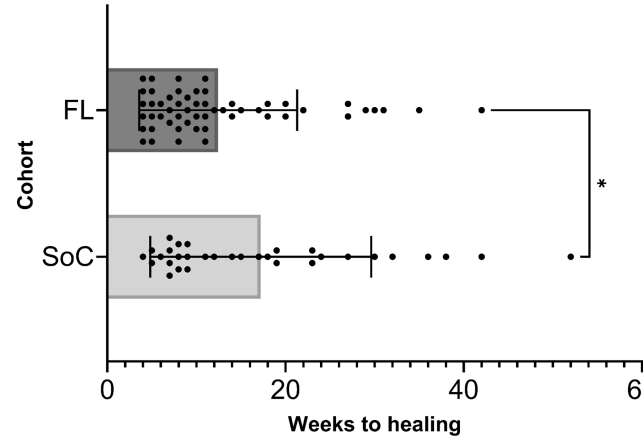
Infection and Serious Complications

The proportion of wounds diagnosed with an infection during the study period (as per *International Classification of Diseases, Tenth Revision* codes linked to the wound of interest) was significantly higher (P = .000, Fisher exact test) in the FL cohort (55.9%, 52/93) compared with the SoC group (26.9%, 18/67; Figure 3). However, significantly fewer wounds in the FL cohort developed infection-associated complications including cellulitis, osteomyelitis, gangrene, wound-associated hospitalization, and sepsis. Specifically, complications instance was 75.3% lower in the FL cohort (P = .007, Fisher exact test), where 12 of 71 SoC wounds experienced complications (16.9%) versus 4 of 96 wounds in the FL cohort (4.2%; Figure 3).

Sampling

A total of 35 of 167 wounds were sampled for microbiological analysis: 17 SoC wounds (23.9%) and 18 FL wounds (18.8%). This equates to a statistically insignificant 21.7% decrease in sampling among the cohort exposed to FL imaging (P = .45, Fisher exact test). Among the wounds diagnosed with an infection, 12 of 18 in

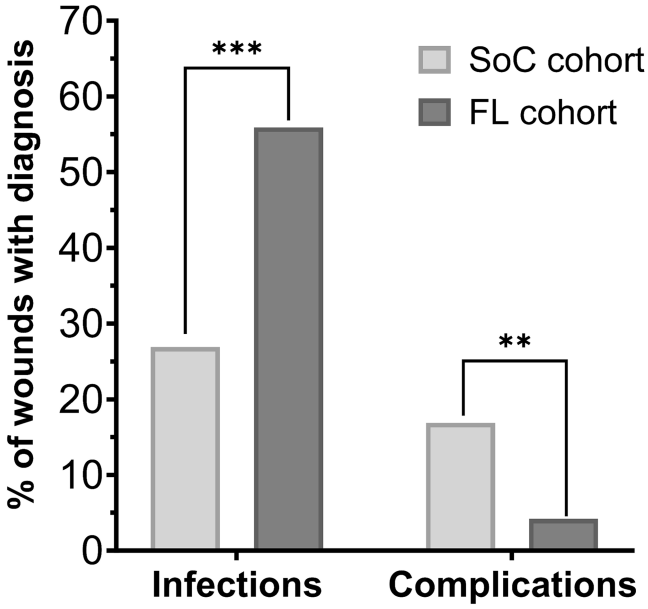
Figure 2. AVERAGE DURATION OF WOUNDS THAT HEALED DURING THE STUDY PERIOD FOR THE SoC (32/71) VERSUS FL (55/96) COHORTS



Abbreviations: FL, fluorescence; SoC, standard of care.
Black bars indicate 95% CIs.
*P < .05.

Figure 3. PROPORTION OF WOUNDS IN THE SoC AND FL COHORTS DIAGNOSED WITH AN INFECTION OR EXPERIENCING A SEVERE INFECTION-ASSOCIATED COMPLICATION DURING THE STUDY PERIOD

Infections counted were directly related to the study wounds, and complications arose from infection in the study wounds, including cellulitis, sepsis, osteomyelitis, gangrene, and/or a wound-associated hospitalization.



Abbreviations: FL, fluorescence; SoC, standard of care.
***$P < .001$.
**$P < .01$.

the SoC cohort (66.7%) were sampled for microbiologic confirmation compared with 17 of 52 in the FL cohort (32.7%).

Antibiotic Use

The amount of antibiotic usage directly linked to the wounds studied differed significantly between the two cohorts ($\chi^2 = 49.83$, $P < .0001$). Systemic antibiotics were more commonly used in the SoC cohort, versus topical antibiotics in the FL cohort (Figure 4). Antibiotics were prescribed for 34 of 71 SoC wounds (47.9%) compared with 69 of 96 wounds the FL cohort (71.9%). Mupirocin and gentamicin ointment were the most prescribed topical antibiotics, whereas amoxicillin-clavulanate and doxycycline were the most prescribed oral antibiotics. The average number of total antibiotic courses prescribed per wound was 0.87 ± 1.33 for SoC (range, 0–5) and 1.57 ± 1.85 for FL (range, 0–7).

The type of antibiotics prescribed differed between the cohorts. In the SoC cohort, 97.1% (33/34) of prescriptions were for systemic antibiotics, 2.9% (1/34) were for topical antibiotics, and none were prescribed both. In the FL cohort, 53.6% (37/69) of antibiotics prescribed included a systemic antibiotic. However, these were frequently prescribed in combination with a topical antibiotic (18/69); 19 of 69 prescriptions were single systemic antibiotics. Nearly half of the FL wounds that received antibiotics were prescribed solely topical antibiotics (32/69, 46.4%). Thus, systemic antibiotic prescribing (either alone or with a topical) was 44.8% lower in the FL cohort (53.6%) compared with the SoC cohort (97.1%).

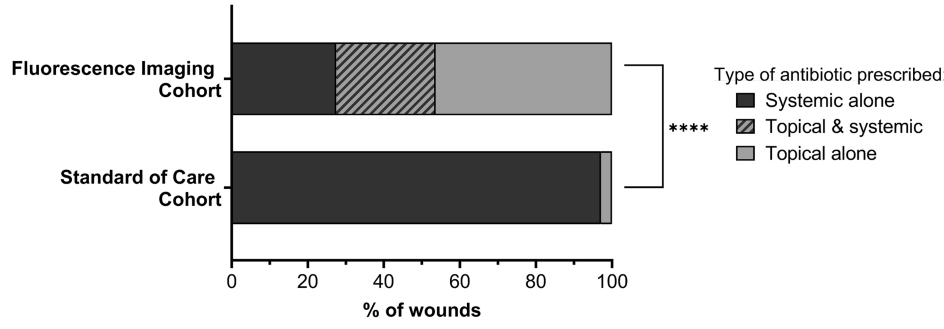
Other Aspects of Clinical Workflow

The proportion of wounds that received at least one debridement procedure tended to be higher in the SoC cohort (83.1%, 59/71) than the FL cohort (63.5%, 61/96); this was near significant ($P = .06$, Fisher exact test). The number of debridement procedures per wound varied widely (range, 0-37) and generally increased the longer the wound remained unhealed. However, the mean number of debridement procedures per wound tended to be higher in the FL cohort (average = 3; 95% CI, 2–4) than for SoC (average = 2; 95% CI, 2–3), although this difference was not statistically significant ($P = .73$). DarkDrapes (MolecuLight) were used in 37% of FL imaging encounters to achieve sufficient darkness if the lights could not be turned down.

DISCUSSION

To the authors' knowledge, this is the first cohort study of FL imaging intervention set in LTC/SNFs and is one

Figure 4. ANALYSIS OF TRENDS IN WOUND-RELATED ANTIBIOTIC PRESCRIBING DURING THE STUDY PERIOD



****$P < .0001$.

of the few real-world, interventional wound care studies focused on this patient population. Improvements in wound healing are greatly needed—the current 12-week healing rate for PIs in US wound care centers is only approximately 30%.[30] This statistic is based on real-world data available in the outpatient setting, and similar data are scarce in LTC/SNFs. However, evidence demonstrates higher wound prevalence and severity and longer healing times for chronic wounds in LTC relative to outpatient care settings.[14] In particular, nursing home residents have a disproportionately higher risk of morbidity associated with infections and are seven times more likely to experience severe sepsis than nonresidents.[17,31,32] This is partly due to the lack of resources allotted to this population, which in itself is a disparity, but also the complexity typical of these patients, which includes clinical and socioeconomic challenges (eg, lack of coverage for advanced therapies; scarcity of on-site resources; and conditions impacting treatment adherence, such as dementia and immobility). These impacts are amplified in patients of color in LTC/SNFs, who experience higher infection rates and more profound healthcare disparities.[26]

As expected in this challenging scenario, the authors observed a 22.5% 12-week wound healing rate among the SoC cohort, which is below the outpatient national average (~30%). However, despite facing the same challenges inherent in this patient base and treatment having occurred immediately following the height of the COVID-19 pandemic, the wound healing rate was higher in the FL cohort (38.5%), nearly 10% above the national outpatient average for PIs. This improvement is similar to the findings of two studies examining healing rates in DFUs. In a tightly controlled RCT based in the UK, 12-week DFU healing rates doubled in the FL-imaged arm (45%) versus the SoC group (22%).[15] In another retrospective outcomes analysis set in an outpatient clinic in the UK, a 23% increase in 12-week DFU healing rate was reported with the implementation of FL imaging in their facility (48% vs 39%).[28] Therefore, the present findings on PIs fall between those of an outpatient, less compromised patient population with DFUs and those of a well-controlled RCT with a younger, healthier cohort of patients with DFUs.

Aside from the percentage of wounds closed at 12 weeks, time to healing is another important endpoint that is relevant to patient quality of life (QoL) and cumulative wound care expenditure. Studies using validated QoL tools demonstrate decreased mobility and self-esteem, inability to perform daily activities independently, and higher rates of anxiety and depression among patients with chronically unhealed wounds.[33] Further, the most impactful driver of Medicare expenditure in wound care is time to heal.[34] The longer a wound remains open, the more resources it exhausts, and the greater its impact on patient QoL.

In the present study, access to the bacterial FL imaging procedure (FL cohort) led patients to heal an average of 4.8 weeks faster than those receiving SoC, and regression modeling suggested a trend toward improved likelihood of healing among FL-imaged wounds. The researchers did not investigate QoL indicators or cost-efficiency, and studies that include these indicators as well as FL imaging are scarce. However, the UK National Health Service reported a 33% cost savings in antimicrobial dressing expenditure and a 47% increase in patient throughput tied to the routine use of FL imaging.[28] They projected a 10% reduction in expenditure per patient per year.[28]

Infections are another barrier to healing that disproportionally impact LTC/SNF residents, particularly older adults. Identifying infection in these patients can be challenging and yet may be pivotal in terms of patient outcomes. Infection rapidly escalates to life-threatening complications requiring hospitalization and specialized intensive care in older and/or multimorbid patients.[17]

The authors observed that infections were diagnosed twice as often in the FL cohort than in the SoC cohort. The increased detection sensitivity likely enabled more timely interventions that resulted in the FL cohort experiencing fewer serious infection-related complications compared with those receiving SoC treatment. It is important to note that not all wounds with bacterial FL signals are infected. Whereas FL imaging identifies bacterial loads above 10^4 CFU/g, infection is generally associated with loads greater than 10^5 or 10^6 CFU/g.[35,36] However, the deleterious effects of chronically present bacterial loads at lower concentrations, recently coined "CIBL" (chronic inhibitory bacterial load) by Armstrong et al,[20] extend beyond infection and impact wound healing by arresting the healing cascade at the inflammatory stage.[12] This preinfection state presents an opportunity for timely intervention and can be diagnosed largely based on FL signals.[20]

Increased detection of covert bacterial loads and localized infection typically prompts more aggressive treatments. In the present study, systemic antibiotic use was greatly reduced in the FL cohort in favor of topical antibiotic prescriptions, and debridement was more common and frequent in the FL cohort. These findings suggest that FL imaging enabled and promoted a shift toward local bacterial management, starting with immediate and targeted action at the bedside.

Repeated, local management is the recommended practice for the management of chronic, hard-to-heal wounds. This is supported by ample evidence, including guideline recommendations,[37,38] and is likely linked to the disturbance of biofilm. There is evidence that more frequent debridement intervals improve chronic wound

healing,[39] and although there is some controversy regarding the utility of topical antibiotics in treating chronic wound infections, their use in conjunction with repetitive, thorough debridement is considered highly effective against biofilm.[40] These benefits of FL imaging are pronounced in the LTC/SNF setting, where clinician skill sets are highly variable, and the increasing presence of multidrug-resistant organisms makes infections more costly to treat and their complications harder to overcome.[17,41]

These conclusions regarding FL-informed treatment plan modifications to better address bacterial loads are supported by dozens of publications in controlled-clinical and real-world settings.[15,21–23,28,42–46] Some studies report improved healing outcomes attributed to these treatment plan changes,[15,28] likely due to the combined effects of earlier elimination of bacterial loads alongside impacts on other aspects of healing (eg, the release of proinflammatory cytokines during FL-guided debridement). A 2021 Delphi consensus outlines an FL imaging-informed treatment decision tree,[47] with an approach similar to the current study and others reporting improvements in healing outcomes.[15]

Strengths and Limitations

A major strength of this research is its setting in LTC/SNFs, where real-world, pre/postintervention studies are infrequently performed but are much needed. Other strengths include the evaluation of wound healing well past 12 weeks and the ability to monitor infection-related outcomes, not solely wound healing rates.

There are, however, several limitations to this study. First, WCP EHRs are limited to the patient's wound care within the facility visited by WCP, and the data herein do not account for when a wound was present before WCP initiated care or after a patient was transferred or discharged. Second, although the number of microbiologic sampling events was recorded, the supporting culture data were not assessed, and therefore, the accuracy of infection diagnoses cannot be confirmed. Further, data regarding dosage and frequency intervals for antibiotics were not assessed and therefore could not be included. Third, given the large proportion of wounds lost to follow-up and the highly complex nature of wounds open for several months due to factors beyond bacterial burden,[48] wound healing data points beyond 24 weeks should be interpreted with caution. Fourth, the inclusion of multiple wounds from the same patient has the potential to create bias because propensity to heal depends on patient-level factors in addition to wound-specific factors (eg, age, comorbidities, patient adherence). The authors strove to limit this bias by including a maximum of three wounds per patient (mean, 1.7 per patient). Finally, the frequency of FL imaging was not examined in this retrospective study; therefore, the point at which wounds started receiving FL imaging scans is unknown (eg, at baseline or several weeks/months into treatment). The timing/frequency of FL imaging intervention is likely to influence wound healing outcomes, so further research aimed at answering these questions could provide crucial insights.

CONCLUSIONS

Patients in LTC/SNFs are prone to healing challenges and infection complications, culminating in disproportionally poor outcomes and high infection rates. Improving these outcomes is necessary to achieve healthcare equity for systemically disadvantaged LTC/SNF patients. The present study highlights FL imaging of wound bacterial location and loads to significantly improve PI wound healing outcomes and reduce infection-associated complications in this context. These improved outcomes have the potential to improve patient well-being, healthcare disparities, and cost to care. These endpoints should be the subject of future research because of the myriad potential benefits to patients, their caregivers, and the healthcare system. ●

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