Literature Review

Outcomes of Telehealth for Wound Care: A Scoping Review

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ABSTRACT

Objective: The aim of this scoping review is to synthesize the literature on delivering wound care via telehealth and compare clinical, healthcare utilization, and cost outcomes when wound care is provided via telehealth (telewound) modalities compared to in-person care.

Data Sources: An electronic search of PubMed, CINAHL, and Cochrane Clinical Trials databases for articles published from 1999-2019 was conducted using the following MeSH search terms: telewound, wound, wound care, remote care, telehealth, telemedicine, eHealth, mobile health, pressure injury, and ulcer.

Study Selection: Articles were included if they were: a scientific report of a single study; evaluated a telehealth method; identified the type of wound of focus; and provided data on clinical, health care utilization, or cost outcomes of telewound care. In total, 26 articles met these criteria.

Data Extraction: Data were extracted and grouped into 13 categories, including study design, wound type, telehealth modality, treatment intervention, and outcomes measured, among others.

Data Synthesis: Of the 26 studies, 19 reported on clinical outcomes including overall healing and healing time; 17 studies reported on healthcare utilization including hospitalizations and length of stay; and 12 studies reported costs.

Conclusions: Evidence regarding the use of telewound care is weak and findings related to the impact of telewound care on outcomes is inconsistent but not inferior to in-person care. Greater use of telehealth as a result of the COVID-19 pandemic points to further development of navigation and education models of telehealth for wound care. However, additional studies employing rigorous research design and leveraging robust sample sizes are needed to demonstrate value.

Keywords: outcomes, pressure injury, telehealth, virtual care, wound care, wound management

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INTRODUCTION

A chronic wound is defined as a wound that has not healed with appropriate progression within 4 to 8 weeks; examples include pressure injuries and diabetic foot ulcers.[1] Research has shown that chronic wounds are a more significant predictor of mortality than coronary artery disease, peripheral arterial disease, or stroke.[2] Moreover, persons with chronic wounds require intensive treatment including frequent assessment and therapy and may experience poor outcomes such as amputation[3] nosocomial infections[4] and significantly diminished quality of life.[3,5,6]

Furthermore, chronic wounds have been associated with significant health care costs.[3,4,7] In fact, in the United States over 6 million chronic wounds account for an estimated $25 billion spent annually on chronic wound treatment, and this burden is and will continue to increase due to high health care costs, an aging population, and higher incidence of comorbidities associated with chronic wounds.[4] The challenges that traditional wound care may pose to patients and health care systems suggest that alternatives to managing these wounds are needed, particularly those that can provide care more quickly; are more convenient for accessing specialists; and can reduce the burden of wound care for providers, patients, and caregivers, including travel time and costs. One such alternative is incorporating telehealth technology into wound care delivery.

Telehealth uses digital technologies such as live video conferencing, still-photo electronic transmission, mobile health apps, and remote patient monitoring to support long-distance delivery of clinical health care.[8,9] Telehealth services can be delivered asynchronously or in real-time (ie, synchronously). Asynchronous telehealth for wound care involves taking still images, uploading those images into the patient's electronic medical record and requesting consultation and/or follow-up by a health care specialist (eg, wound specialist, plastic surgeon, etc.)

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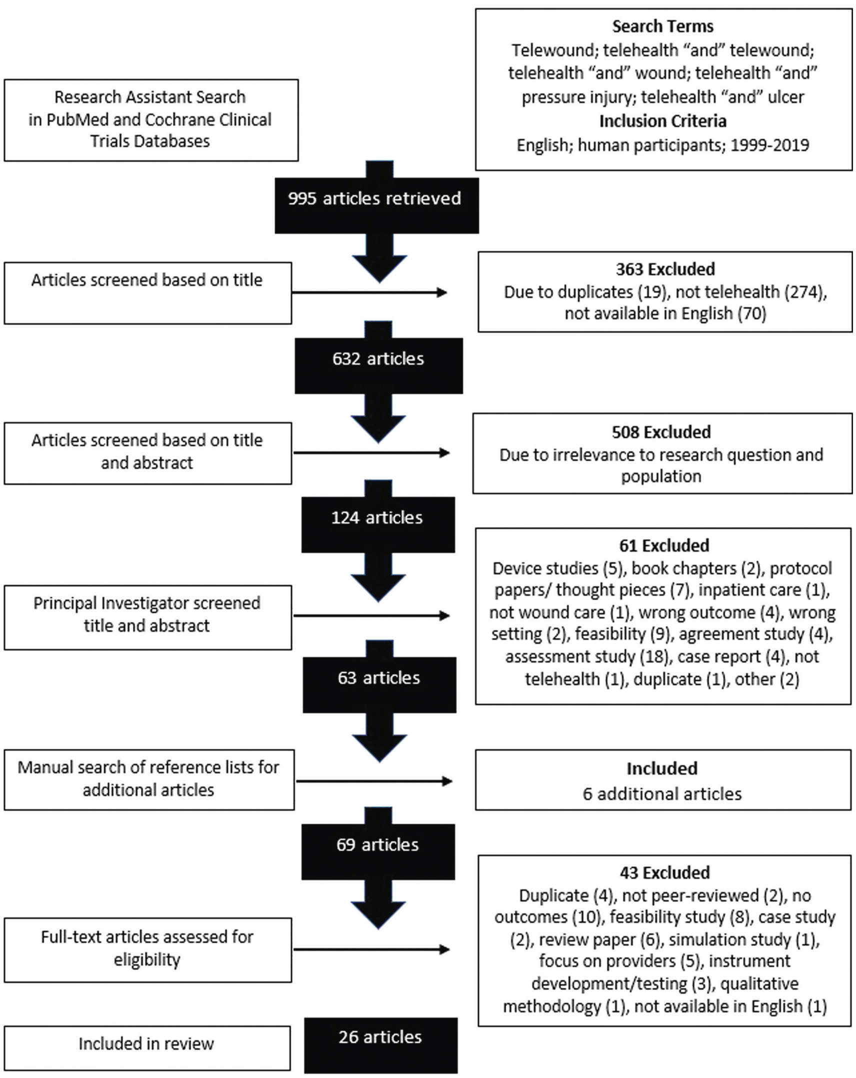
to review the image and provide input into the patient's wound care/management. Alternatively, synchronous telehealth uses video-based platforms to connect a patient from their home or local medical clinic or facility to a wound care specialist in real-time.[10]

Incorporating telehealth into wound care delivery not only facilitates more timely patient access, but can be a more efficient utilization of wound specialists.[10] Specifically, recent literature indicates that telehealth care may decrease patient travel time and travel-related costs, facilitate earlier assessment and treatment of wounds, and improve patient outcomes.[10] Telehealth may be especially beneficial to people who reside in rural areas,[11,12] because it may help reduce their need to travel long distances for specialty wound care clinic visits.[13] The use of telehealth for wound care may also reduce the overall number of clinic visits that patients require, which, in turn, can reduce related costs to the health care system.[6]

Recent research has explored the efficacy and safety of providing traditional (usual, in-person care) versus telehealth for wound care.[1,6,14,15] However, other outcomes related to telehealth for wound care have been explored less frequently, and a comprehensive review of the literature is lacking. Scoping reviews seek to uncover available evidence in a given area and recognize and analyze knowledge gaps in that area.[16] The purpose of this scoping review is to synthesize the literature on incorporating telehealth into wound care delivery (referred to in this paper as 'telewound' care), including examining what outcomes have been assessed and how they compare to outcomes when patients receive usual in-person wound care.

Fig. PRISMA FLOW DIAGRAM



METHODS

This review was conducted by following the five-stage process outlined by Arksey and O'Malley[16] and adapting the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations for scoping reviews.[17] A four-member interprofessional team composed of health services research experts and care providers, including nursing and medicine, conducted the review.

Identifying the Research Question

The aim of this review was to synthesize the body of literature related to telewound care. The specific research question was: "What are the clinical, health care utilization, and cost outcomes of telewound as compared to in-person wound care?"

Identifying Relevant Studies

An electronic search of PubMed, CINAHL, and Cochrane Clinical Trials databases was conducted using the following MeSH search terms individually and in combination: telewound, wound, wound care, remote care, telehealth, telemedicine, eHealth, mobile health, pressure injury, and ulcer, including leg and foot ulcers. Although search terms for surgical wounds were not specifically used, articles discussing postsurgical wounds were considered. The search was limited to articles published from 1999-2019 in the English language with human subjects. This strategy yielded 995 articles which were screened by title. Of these, 19 were duplicates, 274 were not related to telehealth, and 70 were not available in the English language; these articles were subsequently removed from consideration from the final review. An additional 508 articles were excluded as they did not include the relevant interventions. The titles and abstracts of the remaining 124 articles were screened by one of the team members, and an additional 61 articles were excluded (see Figure for additional details), leaving 63 articles for full narrative review. The team manually examined the reference lists of these articles to ensure all potentially appropriate articles were included in the search. This examination resulted in the identification of an additional six articles, for a total of 69. Two team members reviewed the full text of each article independently to determine inclusion or exclusion in the final review, convening a full team discussion to reach consensus when agreement was not initially met.

Study Selection

To answer the research question, inclusion and exclusion criteria were developed. Articles were included if they: (1) were a scientific report of a single study; (2) evaluated a telehealth method; (3) identified the type of wound of focus; and (4) provided data on clinical, health care utilization, or cost outcomes of telewound care. Articles were excluded if they were: (1) literature reviews, (2) reporting qualitative or case study methods, (3) editorial or opinion papers, (4) clinical papers describing wound treatment only, (5) feasibility studies without the outcomes of interest, (6) book chapters, (7) non-peer-reviewed papers, (8) instrument development, (9) non-patient focused, or (10) papers describing the utilization of a software application. To ensure reliable application of the inclusion/exclusion criteria, four team members initially reviewed the full text of the same three articles independently, then met to discuss and reach consensus. The remaining studies were divided among the four team members in pairs for independent review, then again returning to the larger group for discussion and consensus. Of the 69 articles reviewed, 26 were deemed appropriate to answer the research question.

Charting the Data

A data extraction table was created and a total of 13 categories were identified. In addition, definitions of each category were developed, and inclusion/exclusion criteria specified to ensure consistency among reviewers (Table 1). The findings from the articles were individually charted by each team member, then discussed as a team to reach consensus. One to two additional team members reviewed articles where agreement could not be reached initially. The final

Table 1. DEFINITIONS OF CATEGORIES OF DATA EXTRACTION

Category	Definition
Description of sample	Study period, power analysis, sample size
Demographics	Age, gender, race, etc
Study design	Type of study conducted (eg, cohort study)
Wound type	Type of wound studied (eg, pressure injuries)
Type of telehealth	Type of telehealth studied (eg, store-and-forward)
Intervention	Type of treatment/care intervention received by the intervention group
Comparison group	Type of treatment/care intervention received by the comparison group
Outcomes measured	
Clinical	Related to clinical manifestation (eg, amputation, healing time, etc)
Health care	Related to health care utilization (eg, length of stay, number of visits, etc)
Cost	Related to cost (eg, inpatient cost, cost savings, wound management cost, etc)
Results	Results/conclusion of the study
Comments	Additional comments about the article Note any article that might be subsumed in another article
Inclusion/exclusion	Include or exclude an article based on the criteria; if excluded, rationale stated

Table 2. **CLINICAL OUTCOMES OF TELEHEALTH FOR WOUNDS**

Author (Year), Geographic Location	Wound Type	Sample Characteristics: TH	Sample Characteristics: Comp	TH[a]/Comp[b] Groups	Clinical Outcomes: TH	Clinical Outcomes: Comp
Assimacopoulos et al (2008),[28] US	Bacterial wound infections	n = 48 Male, 44% Mean age, 66 y 54% had bacterial wound infections	n = 59 Male, 63% Mean age = 60 y 46% had bacterial wound infections	TH: Interactive video at rural hospital Comp: Usual care	Days on IV antibiotics: mean, 6.913 Percent survival, 0.894	Days on IV antibiotics: mean, 13.345; $P = 0$ Percent survival, 0.948; $P = .112$
Binder et al (2007),[30] Austria	Leg ulcers: venous and mixed	N = 16 Male, 25% Median age, 73 y years (range, 47-86 y) Total of 45 ulcers	NA	SFT with home care nurse	Ulcer size: 71% decreased in size, of which 14 healed completely; 10 ulcers increased in size; 3 were not able to be assessed	NA
Gamus et al (2019),[26] Israel	Lower extremity ulcers	n = 277 Male, 67% Age > 60 y, 70.5% diabetic ulcer, 21.3%; multiple ulcers, 66%	n = 373 Male, 63.8% Age > 60 years, 70.4% diabetic ulcer, 23.9%; multiple ulcers, 64%	TH: CVT Comp: Usual care	Healed ulcers: 52% Mortality rate: OR = 1.82 (CI:0.77,4.01); $P = 0.078$	Healed ulcers: 55%; $P =$ ns
Garcia et al (2018),[18] US	Burns, pediatric	n = 32 Age (mean ± SD), 4.9 ± 4.3 y (range, 1-17 y)	n = 35 Age (mean ± SD), 5.1 ± 4.8 y (range, 1-15 y)	TH: Smartphone app (TeleBurn) for sharing images, videoconference, instant messages, and instructional videos Comp: Usual care	Days to heal (mean ± SD), 11.6 ± 4.7 Adherence to completing therapy: 80%	Days to heal (mean ± SD), 14.3 ± 5.4; $P = .03$ Adherence to completing therapy: 64%; $P = .09$
Hickey et al (2017),[31] US	Burns	N = 31 Males = 27 Mean age, 44 y (range, 18-83 y)	NA	Home TH with some SFT	No complications	NA
Le Goff-Pronost et al (2018),[19] France	Complex chronic wounds	n = 77 Male, 46.7% Mean age, 75.8 y (range, 22-97 y)	n = 39 Male, 61.5% Mean age, 67.2 y (range, 24-95 y), $P < .05$	TH: Local MD and home care nurse using SFT with home video Comp: Usual care with dermatologist	Days to heal: 132.6 Wounds with improvement: 66% Mortality: n = 11 (14%)	Days to heal: 182; $P < .05$ Wounds with improvement: 61%; $P < .05$ Mortality: N = 2 (5%); $P < .05$
Mousa et al (2019),[29] US	Vascular surgical incisions	n = 16 Male, 62.5% Age (mean ± SD), 62.5 ± 7.2 y	n = 14 Male, 42.9% Age (mean ± SD), 65.7 ± 7.3 y	TH: Tablet with monitoring devices Comp: Usual care	30-day infection rates: 31.3%	30-day infection rates: 7.1%; $P = 0.17$
Rasmussen et al (2015),[27] Denmark	Diabetic foot ulcers	n = 193 Male, 78% Age (mean ± SD), 66.8 ± 13.0 y	n = 181 Male, 71% Age (mean ± SD), 66.7 ± 12.8 years	TH: Telephone consults Comp: Outpatient visits	Number of patients with complete healing: 138 Number of patients with amputations: 21 Mortality: 8	Number of patients with complete healing: 133, HR 1.11; P = .42 Number of patients with amputations: 26, HR 0.87; $P = .59$ Mortality: 1, HR 8.68; $P = .0001$
Ratliff & Forch (2005),[32] US	Wounds in geriatric patients	N = 9 Males = 4; Mean age, 82 y (range, 73-94 y)	NA	Interactive video with long term care facility and wound provider at hospital	All wounds healed	NA
Smith-Strøm et al (2018),[22] Norway	Diabetic foot ulcers	n = 94 Male, 74% Age (mean ± SD), 66.4 ± 16.6 y Married, 56.6%	n = 88 Male, 74% Age (mean ± SD), 65.5 ± 16.5 y Married, 63.3%	TH: Clinic TH using mobile phones with SFT Comp: Outpatient clinic	Amputations: 6 Patients with complete ulcer healing: 75 Months to healing (for those that healed): 3.4 Mortality: 5	Amputations: 13 Patients with complete ulcer healing: 67 Months to healing (for those that healed): 3.8; $P =$ ns Mortality: 5; $P =$ ns

(continues)

Table 2. CLINICAL OUTCOMES OF TELEHEALTH FOR WOUNDS, CONTINUED

Author (Year), Geographic Location	Wound Type	Sample Characteristics: TH	Sample Characteristics: Comp	TH[a]/Comp[b] Groups	Clinical Outcomes: TH	Clinical Outcomes: Comp
Sood et al (2016),[33] France	Pressure injuries, leg ulcers	N = 5,795 Male, 48.5%; Mean age, 89 y	NA	Home TH with data entry and SFT	58% of patients had positive outcomes: 30% had complete healing and 28% had improvement; 27% had no change; 16% got worse	NA
Terry et al (2009),[24] US	Pressure injuries, nonhealing surgical wounds	n = 40 Male, 35% Age (mean ± SD), 58.4 ± 18.2 y; Race: White, 20%; Black, 73%; Other, 8%	Spec: n = 28 Male, 29%; Age (mean ± SD), 58.2 ± 17.7y Race: White, 25%; Black, 75% Comp: n = 35 Male, 29% Age (mean ± SD), 57.5 ± 15.9 y Race: White, 26%; Black, 51%; Other, 23%	TH: Home TH w/SFT and specialist consults Spec: Usual care with wound specialist Comp: Usual care	Days to heal (SD): 40 (25) Pressure injuries days to heal (SD): 66 (39) Wound healing: 11% healed 74% improved	Days to heal (SD): Spec, 29 (15); Comp, 33 (23); $P = .008$ Pressure injuries days to heal (SD): Spec, 31 (21); Comp, 46 (33); $P = .022$ Wound healing: Spec: 36% healed, 57% improved Comp: 16% healed, 72.5% improved
Turk et al (2011),[36] Turkey	Burns	N = 187 Males, 67.4% Age (mean ± SD), 21.9 ± 19.9 y (range: 0-90 y)	NA	SFT, interactive video and phone	Mortality: 9 (4.8%)	NA
Vesmarovich et al (1999),[35] US	Pressure injuries	N = 8 Male, 100% Race: White, 80% African American, 40% Mean age, 49.8 y (range, 38-78 y)	NA	Home TH with SFT	7 of 12 ulcers healed completely (58%)	NA
Vowden & Vowden (2013),[23] United Kingdom	Any wounds in nursing home	n = 17 Males, 41% Age range, 66-92 y; Total wounds = 23	n = 9 Males, 44% Age range, 51-95 y; total wounds = 11	TH: Smart phone with camera, digital paper-pencil tech, and mobile phone Comp: Usual care	Duration mean: 10 months 16 healed (70%), 2 not healed, 3 died (18%), 1 withdrawn.	Duration mean: 15 months 2 healed (18%), 6 not healed, 1 died (11%), 1 withdrawn, 1 lost to follow-up
Wickström et al (2018),[20] Sweden	Hard-to-heal ulcers (eg, diabetic foot ulcers, pressure injuries)	n = 100 Male, 46% Age (mean ± SD), 77 ± 13 y (range, 37-98 y)	n = 1,888 Male, 44%; $P =$ ns Age (mean ± SD), 75 ± 14 y (range, 23-104 y); $P =$ ns	TH: Home TH and CVT Comp: Usual care	Days to heal (median): 59	Days to heal (median): 82; $P < .001$
Wilbright et al (2004),[21] US	Forefoot ulcerations	n = 20 Male, 45% Mean age, 55.1 y wound grade = 1.42	n = 120 Male, 55% Mean age, 56.5 ; $P =$ ns; wound grade = 1.78, $P = .023$	TH: CVT (from local facility) Comp: Specialty clinic	Days to heal (SD): 43.0 (29.3) Percentage of wounds healed in 12 weeks: 75% Healing time ratio adjusted for demographics: 1.4	Days to heal (SD): 45.5 (43.4); $P =$ ns Percentage of wounds healed in 12 weeks: 81%; $P = .546$ Healing time ratio adjusted for demographics: 1; $P = .104$

(continues)

Table 2. **CLINICAL OUTCOMES OF TELEHEALTH FOR WOUNDS**, CONTINUED

Author (Year), Geographic Location	Wound Type	Sample Characteristics		TH[a]/Comp[b] Groups	Clinical Outcomes	
		TH	Comp		TH	Comp
Wilkins et al (2007),[34] US	Lower extremity ulcers, peripheral vascular ulcers, pressure injuries, other wounds	N = 56 Male, 100% Mean age, 66 y Total of 88 wounds (1-9 per patient)	NA	SFT	Size of ulcers available for 20 patients/37 wounds: 76% (n = 28) ulcers decreased in size and 24% (n = 9) increased.	NA
Zarchi et al (2015),[25] US	Chronic wounds of legs/feet	n = 50 Age (mean ± SD), 78.4 ± 14.4 y	n = 40 Age (mean ± SD), 74.2 ± 10.6 y, $P = .027$	TH: SFT with home care nurses Comp: Home care	Complete wound healing over 1 year: 70% Mortality: 1	Complete wound healing over 1 year: 45%; HR 2.1; $P = .017$ Mortality: 4; HR 0.24; P = ns

Abbreviations: Comp, comparison group; CVT, clinical video telehealth; NA, not applicable; ns, not significant; SD, standard deviation; SFT, store and forward; Spec, group receiving usual care with a wound specialist; TH, telehealth.
[a]TH represents any type of telehealth utilized in the study
[b]Comp represents the comparison or control group

decision for including or excluding the article was recorded on the data extraction table by the principal investigator.

RESULTS

The final group of 26 articles focused on telewound care, with half published in the past 5 years (Supplemental Table, http://links.lww.com/NSW/A##). These articles reported on the application of telewound care for a variety of wounds ranging from diabetic and venous leg ulcers to burns, surgical incisions, and pressure injuries. Approximately 40% of the articles reported on research conducted in countries other than the United States, including Australia, Austria, Denmark, France, Israel, Norway, Sweden, Turkey, and the United Kingdom. Study designs included retrospective and prospective observational studies, nonequivalent control studies, and a few randomized clinical trials. Sample sizes varied widely from small (Ns of 9 and 14) to very large (Ns in the thousands). Telewound settings included patient homes, a local or remote clinic or hospital, and a nursing home. Further, telehealth strategies included store-and-forward (SFT), hospital and clinic video telehealth (CVT), and in-home video telehealth.

Outcomes assessed varied by study. Three sets of outcomes most often reported in these studies were examined: clinical outcomes, health care utilization, and costs. The clinical outcomes most often reported were healing outcomes, including wounds that completely healed or wounds that improved over time, wound size, complications including infections, amputations, and mortality. There was no standardization across studies in terms of how healing was assessed or the time period in which it was assessed.

Clinical Outcomes

A total of 19 studies reported clinical outcomes related to telewound care (Table 2). Twelve studies compared clinical outcomes between a group of patients who received telewound care and a comparison group (including pre/post and historical comparisons). Seven studies specifically examined healing time, comparing telewound with usual care. Healing time was significantly shorter among those who received telewound care in three studies[18,19,20] and did not differ significantly from the comparison/usual care in three others.[21,22,23] Terry et al,[24] however, reported significantly more days to heal pressure injuries and other chronic wounds among patients who received telewound care than those who received usual care. Seven studies reported on the proportion of wounds that healed. Zarchi et al[25] reported a significantly higher proportion of healed ulcers among patients who received telewound care. Smith-Strøm et al[22] and Vowden and Vowden[23] also found a higher proportion of healing among the telewound group, but these studies did not provide p-values. Gamus et al[26] and Terry et al[24] found that usual care had higher proportions of healing compared to the telewound group; however, these studies did not conduct statistical analyses comparing these groups. Two studies did not find a difference in the percent of wounds healed.[21,27] The time used to assess healing varied considerably across studies and, as such, further comparison was not possible.

Seven studies compared rates of mortality over the course of the study between individuals who received telewound care and those who received usual care. Three studies reported greater mortality among individuals who received telewound care; specifically, mortality was higher in the telewound group in the studies by Rasmussen et al[27] ($P = .0001$), Gamus et al[26] ($P = .078$), and LeGoff-Pronost et al[19] ($P = .05$). Although the authors noted that they could not identify a link among variables under study and mortality, they suggested that further investigation into patients' comorbidities, mortality, and the use of telewound care should be conducted. In addition, Vowden and Vowden[23] also reported a higher number of deaths among patients who received telewound care compared with those who received usual care (18% vs 11%); however, no statistical analyses were conducted comparing these groups. Three studies did not find a difference in mortality between individuals who received telewound care and comparison groups.[22,25,28]

Amputation rates were examined in two studies.[22,27] Neither study reported a statistically significant difference in amputation rates among individuals who received telewound versus usual care, although both reported fewer amputations in the telewound group. Assimacopoulos et al[28] assessed days on IV antibiotics and found that individuals who received telewound care averaged 7 days whereas the comparison group patients averaged 13 days ($P = 0$).28 Mousa et al[29] reported a higher, but not statistically significant, 30-day infection rate among individuals who received telewound care (31.3%) versus usual care (7.1%; $P = 0.17$).

Six of the seven studies that did not include a comparison group examined wound healing over time.[30–35] Turk et al[36] reported a 4.8% mortality rate for patients with burns managed with telewound care. However, without data from a comparison group, no conclusions were able to be determined on whether the patients who received telewound care in these studies would have conferred similar, better, or worse outcomes had they received usual care.

Healthcare Utilization

Seventeen studies reported on healthcare utilization outcomes, including hospitalizations and inpatient length of stay (eg, hospital days), consults, clinic visits, and waiting time for consults (Table 3). Three studies examined inpatient length of stay related to wounds.[24,28,37] Rees and Bashshur[37] found that individuals who received telewound care had a shorter length of stay than those in the historical comparison group, by which individuals were matched by wound type, comorbidities, distance of residence to clinic, payer mix, and care provided by the same surgeon at the same outpatient clinic (21.0 vs 38.5 days; $P = .017$). Assimacopoulos et al[28] also found use of fewer hospital days for bacterial wound infections managed by telewound versus usual care, whereas Terry et al[24] did not report significant differences in length of stay by group. Rees and Bashshur[37] reported fewer hospital admissions among individuals who received telewound care than the comparison group, but Mousa et al[29] did not find a difference in hospital readmission rates among the telewound and comparison groups. Other outcomes examined included number of clinic visits (which did not differ in the results reported by Rees and Bashshur[37] or Mousa et al[29]), and home visits made by a nurse. The studies by Mousa et al[29] and Smith-Strøm et al[22] found no difference in number of nurse home visits between individuals who received telewound care and those in the comparison groups; however, the number of visits was higher for those who received telewound care in the study by Terry et al[24] (27 vs 18 visits; $P = .043$). In addition, Garcia et al[18] reported fewer clinical encounters overall for individuals who received telewound care than those who received usual care.

Consult visits varied by study. Le Goff-Pronost et al[19] reported greater consult visits among individuals who received telewound care as compared with usual care, Binder et al[30] reported a decrease in SFT consults required after telewound care was introduced in their pre/post design, and Smith-Ström et al[22] found no difference in the number of consults completed between their telewound and comparison groups. Further, Wickstrom et al[20] reported a shorter waiting time for wound care among individuals who received telewound care (mean, 25 days; range, 1-83 days) than those in the comparison group (mean, 43 days; range, 3-294 days) ($P = .017$).20 Three of the four studies that involved pressure injuries and other hard-to-heal wounds reported lower healthcare utilization, including emergency department visits, inpatient hospitalizations,[37] nursing visits,[24] waiting time for wound care[20] and inpatient length of stay[24,37] among individuals who received telewound care than those in the comparison group.

Seven studies that presented healthcare utilization data did not include a comparison group. Three of these studies used a retrospective chart review to estimate reductions in utilization[33,38,39] and one summarized the utilization of telewound care.[36] Hoffman-Wellenhoff et al[40] reported a significant decrease in visits to the physician and wound care clinic, but did not provide actual numbers. Two studies were feasibility studies, one reported response time to telewound consultations[34] and the other reported on admissions to the burn unit and length of stay.[31]

Costs

Cost-associated outcomes related to wound care included total costs, costs per patient, hospital, and patient transportation and/or travel costs. Twelve studies reported cost data (Table 4), but only four included comparisons between telewound care and usual care.[19,24,37,41] Fasterhodt et al[41] found no difference in total costs per patient between individuals who received telewound care and those who received usual care, whereas Terry et al[24] reported higher total costs for persons who received telewound care compared with the nontelehealth (usual care) and control group (no telehealth and no consults with a wound care specialist; no p-value reported).

Table 3. HEALTHCARE UTILIZATION OUTCOMES FOR TELEHEALTH AND COMPARISON GROUPS

Author (Year), Geographic Location	Wound Type	Sample Characteristics		TH[a]/Comp[b] Groups	Healthcare Utilization Outcomes	
		TH	Comp		TH	Comp
Assimacopoulos et al (2008),[28] US	Bacterial wound infection	n = 48	n = 59	TH: Interactive video at rural hospital Comp: Usual care	Days hospitalized (mean): 6.48	Days hospitalized (mean): 10.69; $P = .016$
Binder et al (2007),[30] Austria	Leg ulcers; venous and mixed	N = 16	NA	SFT with home care nurse: Pre/post	Pre-period (3 months prior to start of telehealth): Number of consults = 64	Postperiod: Number of consults = 9
Gamus et al (2019),[26] Israel	Lower extremity ulcers	n = 277	n = 373	TH: CVT Comp: Usual care	Visits (mean ± SD), 7.74 ± 6.79	Visits (mean ± SD), 9.18 ± 11.02; P = ns
Garcia et al (2018),[18] US	Burns, pediatric	n = 32	n = 35	TH: Smartphone app (TeleBurn) for sharing images, videoconference, instant message, and instructional videos Comp: Usual care	Clinical visits (mean ± SD), 0.93 ± 0.6	Clinical visits (mean ± SD), 3.3 ± 1.0; $P = .001$
Hickey et al (2017),[31] US	Burns	N = 31	NA	Home telehealth with some SFT	Number admitted to burn unit: 29 Length of stay (mean): 13.6 days (range, 1-77 days)	NA
Hofmann-Wellenhof et al (2006),[40] Australia	Chronic leg ulcers	N = 14	NA	SFT	Significant decrease in the number of visits to general physicians or the wound care center compared to pre-TH period (data on reported)	NA
Le Goff-Pronost et al (2018),[19] France	Complex chronic wounds	n = 77	n = 39	Local MD and home care nurse SFT with home video vs. Usual care with dermatologist	Mean number of consult visits (range): 4.3 (2-10)	Mean number of consult visits (range): 3.7 (1-5); $P < .05$
Liu et al (2017),[38] US	Burns	N = 29	NA	TH from rehab facility and acute burn hospital outpatient clinic	29 patients had 73 weekly TH visits (equivalent of 6.8 burn clinic days saved); 16 same-day surgeries scheduled during TH visit (saving 5 hospital days per patient or 80 total days); avoided 146 ambulance transports	NA
McWilliams et al (2016),[39] Australia	Burns, pediatric	N = 904 Male, 58.1% Age range, 3 wks – 16 y	NA	SFT and telephone consult	4,905 avoided bed days; 364 avoided acute transfers over an 8-year observation period	NA
Mousa et al (2019),[29] US	Vascular surgical incisions	n = 16	n = 14	TH: Tablet w/monitoring devices Comp: Usual care	Number of any 30-day hospital readmissions: 4 Number of unplanned clinic visits: 2 Visiting nurse visits (mean ± SD): 1.3 ± 2.9	Number of any 30-day hospital readmissions: 2; P = ns Number of unplanned clinic visits: 1; P = ns Visiting nurse visits (mean ± SD): 1.4 ± 2.9; P = ns
Rees & Bashshur (2007),[37] US	Chronic wounds	n = 19 Male = 11	n = 19 Male = 7	TH: SFT with home health nurse Matched historical group: Usual care	ED visits (mean): 0.84 Outpatient visits (mean): 11.12 Hospital admission (mean): 2.63 Hospital days (mean): 21	ED visits (mean): 2.05; $P = .049$ Outpatient visits (mean): 10; P = ns Hospital admission (mean): 4.89; $P = .045$ Hospital days (mean): 38.53; $P = .017$

(continues)

Table 3. **HEALTHCARE UTILIZATION OUTCOMES FOR TELEHEALTH AND COMPARISON GROUPS**, CONTINUED

Author (Year), Geographic Location	Wound Type	Sample Characteristics		TH[a]/Comp[b] Groups	Healthcare Utilization Outcomes	
		TH	Comp		TH	Comp
Smith-Strøm et al (2018),[22] Norway	Diabetic foot ulcer	n = 94	n = 88	TH: Clinic telehealth using mobile phones with SFT Comp: Outpatient clinic	Consults at clinic per month (mean ± SD): 2.0 ± 1.9 Community nurse visits per month (mean ± SD): 6.7 ± 3.4	Consults at clinic per month (mean ± SD): 2.5 ± 3.0; P = ns Community nurse visits per month (mean ± SD): 5.9 ± 4.6; P = ns
Sood et al (2016),[33] France	Pressure injuries, leg ulcers	N = 5,795	NA	Home telehealth with data entry and SFT	67% of responding providers reported that unplanned hospitalizations could be avoided using model; 87% thought it decreased length of stay	NA
Terry et al (2009),[24] US	Pressure injuries, nonhealing surgical wounds	n = 40	Spec: n = 28 Comp: n = 35	TH: Home telehealth w/SFT and specialist consults Spec: Usual care with wound specialist Comp: Usual care	Length of stay (days): 51 Nurse visits/year: 27	Length of stay (days): Spec, 36; Comp, 40; P = ns Nurse visits/year: Spec, 13; Comp, 18; P = .043
Turk et al (2011),[36] Turkey	Burns	N = 187	NA	SFT, interactive video and phone	11.2% transferred to referral center; Mean ± SD hospital stay: 6.4 ± 13.4 days; over 5-year period number of patients increased, while number of telehealth visits and number transferred both decreased	NA
Wickström et al (2018),[20] Sweden	Hard-to-heal ulcers (eg, diabetic foot ulcers, pressure injuries)	n = 100	n = 1,888	TH: Home telehealth and CVT Comp: Usual care	Days waiting time for consult (median): 25	Days waiting time for consult (median): 32; P = .017
Wilkins et al (2007),[34] US	Lower extremity ulcers, peripheral vascular ulcers, pressure ulcers, other wounds	N = 56	NA	SFT	Mean response time for consultations (days): 2.61 (range, 1 – 7)	NA

Abbreviations: Comp, comparison group; CVT, clinical video telehealth; NA, not applicable; ns, not significant; SD, standard deviation; SFT, store and forward; Spec, group receiving usual care with a wound specialist; TH, telehealth.
[a]TH represents any type of telehealth utilized in the study
[b]Comp represents the comparison or control group

Both Rees and Bashshur[37] and Le Goff-Pronost et al[19] reported lower hospital costs among patients who received telewound care, but neither reported p-values for significance.

Nine studies examined costs related to patient travel or transportation. Only one study had data from a comparison group,[19] whereas the others most often based their cost/savings estimates on what would have been required in terms of trips to the clinic or hospital if the patients had not received telewound services;[30–32,38–40,42,43] all these studies reported lower patient travel or transportation costs as a result of telewound care. Specifically, Lui et al[38] reported a reduction in ambulance trips after telewound care use began. McWilliams et al[39] determined hospital and transfer costs were avoided due to the provision of telewound care. LeGoff-Pronost et al[19] found a significant reduction in travel costs for the telewound group. Unfortunately, due to the lack of comparison group data for most studies, drawing any conclusions regarding cost savings due to telewound care would be premature.

DISCUSSION

Incorporating telehealth into the provision of wound care has great appeal for patients, family caregivers, and providers. Telewound care may result in patient and family caregiver avoidance of time-consuming and costly trips from their home to a wound specialist while

Table 4. HEALTHCARE COSTS FOR TELEHEALTH AND COMPARISON GROUPS

Author (Year), Geographic Location	Wound Type	Sample Characteristics TH	Sample Characteristics Comp	TH[a]/Comp[b] Groups	Cost Outcomes TH	Cost Outcomes Comp
Binder et al (2007),[30] Austria	Leg ulcers: venous and mixed	N = 16		SFT with home care nurse	46% reduction in transportation costs for the insurance company	NA
Fasterholdt et al (2018),[41] Denmark	Diabetic foot ulcers	n = 193	n = 181	TH: SFT and telephone consult with home care nurse Comp: Usual care	Total costs per patient (mean): €12,356	Total costs per patient (mean): €14,395; $P = 0.42$
Hickey et al (2017),[31] US	Burns	N = 31	NA	Home TH with some SFT	Distance saved: 188 miles (range, 4-822); time traveled saved: 201 min (range, 20-564); costs saved in mileage: $108.50 per patient	NA
Hofmann-Wellenhof et al (2006),[40] Australia	Chronic leg ulcers	N = 14	NA	SFT	67% reduction in transport costs of the patient compared to pre-TH period	NA
Le Goff-Pronost et al (2018),[19] France	Complex chronic wounds	n = 77	n = 39	TH: Local MD and home care nurse SFT with home video Comp: Usual care with dermatologist	Cost of hospitalization per patient (mean): £ 6,323.90 Travel cost per patient: £ 604.93	Cost of hospitalization per patient (mean): £ 9,024.3; P = ns Travel cost per patient: £ 1294.53; $P < .05$
Liu et al (2017),[38] US	Burns	N = 29	NA	TH from rehab facility and acute burn hospital outpatient clinic	146 ambulance transports averted resulted in cost savings of $101,110	NA
Massman et al (1999),[42] US	Burns	N = 40 Male, 93% Mean age, 29 y (range: 1-71 y)	NA	CVT between clinics and burn hospital	Total round-trip travel savings (used 1998 IRS mileage costs) $16,186 Average savings per patient $405	NA
McWilliams et al (2016),[39] Australia	Burns, pediatric	N = 904		SFT and telephone consult	Avoided transfer and bed days in 2012/2013 was AUD 6,460/patient (total AUD 1.89 million)	NA
Nguyen et al (2004),[43] US	Burns	N = 294 Male, 84% Mean age, 31.2 y (range, <1-96 y)		Interactive video and SFT	Average cost saved in travel per patient: $146	NA
Ratliff & Forch (2005),[32] US	Wounds in geriatric patients	N = 9	NA	Interactive video with long term care facility & wound provider at hospital	Transportation cost savings of $650 per visit for a total of $13,650 for 21 visits; Cost savings of $110.12 for TH chronic wound care consult vs previously identified usual care consults	NA
Rees & Bashshur (2007),[37] US	Chronic wounds	n = 19	n = 19	TH: SFT with home health nurse Comp: Matched historical group – usual care	Hospital costs from year 1 to 2: $22,481 to $6,422 Outpatient costs from year 1 to 2: $6,224 to $6,408 Wound care costs from year 1 to 2: $3,237 to $1,615	Hospital costs from year 1 to 2: $24,200 to $22,405 Outpatient costs from year 1 to 2: $2,293 to $1,494 Wound care costs from year 1 to 2: $10,174 to $5,593
Terry et al (2009),[24] US	Pressure injuries, nonhealing surgical wounds	n = 40	Spec, n = 28 Comp, n = 35	TH: Home TH w/SFT and specialist consults Spec: Usual care with wound specialist Comp: Usual care	Total cost/patient (mean): $4,022	Total cost/patient (mean): Spec, $1937; Comp, $2596 (no P provided)

Abbreviations: AUD, Australia dollars; Comp, comparison group; CVT, clinical video telehealth; NA, not applicable; ns, not significant; Spec, group receiving usual care with a wound specialist; SFT, store and forward; TH, telehealth.
[a]TH represents any type of telehealth utilized in the study
[b]Comp represents the comparison or control group

allowing providers to manage their patients in their own homes or local clinics, potentially improving access to wound care and improving associated outcomes. However, data on outcomes of telewound care are very limited. This scoping review examined the existing literature to determine what outcomes data were available and what gaps exist in understanding the impact of telewound services. However, outcomes data in the existing literature are quite limited, as many published studies used observational designs that lacked true comparison groups; in addition, definitions of how outcomes are measured across published studies vary considerably.

More positively, the variation in the literature speaks to the range and flexibility of telewound programs that have been developed to facilitate remote delivery of specialty wound care services. Many programs have used a combination of telehealth options such as SFT and home telehealth, often with a home care nurse present. With respect to clinical outcomes, four articles indicated that mortality was higher among individuals who received telewound care as compared with those who received usual care[19,23,26,27] whereas three other studies found no differences in mortality.[22,25,28] Notably, the populations in studies reporting higher mortality were older. Further research on the relationship between receiving telewound care and mortality is needed.

The impact of telewound care on healthcare utilization had varying results. Several studies reported fewer hospitalizations, hospital days, in-person or clinic visits, emergency room visits, and/or waiting time for care among those receiving telewound care, but others reported no differences among individuals who received telewound and usual care. Two studies reported more consult or nurse visits as a result of telewound care,[19,24] one study found a decrease in consults or visits,[18] and three studies found no difference.[22,29,37] These studies represent a variety of patient populations with respect to type of wounds, age of participants, and the types of care provided, and, as such, it is difficult to compare the effects that telewound care had on outcomes. Generally speaking, telehealth programs expect to provide care that is at least comparable to usual care, and it would appear that, with respect to healthcare utilization, this was the case in this review.

The assessment of costs across the literature was particularly weak. The studies that included cost data had limited comparison groups (nontelehealth), measured different costs (eg, hospital costs, costs of home visits, travel), and mixed patient costs with health system costs. One consistent finding was that telewound care was associated with reduced travel or transportation costs for patients.[19,30–32,38–40,42,43] This finding is not surprising, however, it is important to note that only the study by LeGoff-Pronost et al[19] included a comparison group, and studies without a comparison group may not have considered other travel costs related to wound care (eg, travel to the emergency room for a wound-related complication or ambulance transfers from community nursing homes to wound care clinics).

The findings related to costs are similar to those reported in other studies of telemedicine available in the literature. De la Torre-Diez et al[44] conducted a review of the cost-effectiveness of telemedicine, electronic, and mobile health programs. The majority of the studies included in this review were not randomized trials, had small sample sizes, and lacked quality data and appropriateness measures. Similarly, Ekeland et al[45] conducted a systematic review of telemedicine interventions. Of the 80 articles included, 21 indicated that telemedicine was effective, 18 appeared promising but had incomplete evidence, and the other 41 (51%) had evidence that was limited and inconsistent.

Although the majority of studies included in this review suggest that telewound care is comparable to or better than traditional usual care, the weak designs (including lack of a comparison or control group) and variations in the telehealth programs used, types of wounds that were managed, and patient populations included (eg, pediatric, disabled, elderly, long-term care residents) make it difficult to draw solid conclusions from this scoping review about the impact of telewound care on outcomes as compared to usual care. Telehealth encompasses a variety of technologies, strategies, and care providers. Telehealth programs that are effective with one population or in a specific setting may have different impacts in other care contexts. Findings from this scoping review align with the conclusions of several other reviews, indicating that future studies exploring telewound programs should leverage rigorous research designs, including use of standard, well-defined outcome measures, in order to evaluate their effectiveness more broadly.

This review included articles published between 1999 and 2019. In 2020, the COVID-19 pandemic necessitated a palpable shift in how healthcare services were delivered. Although telehealth technologies have existed for several years, prior to the COVID-19 pandemic, their adoption was limited (albeit slowly increasing).[46] During the COVID-19 pandemic, the US Centers for Disease Control and Prevention encouraged the use of telehealth to increase access to healthcare services while reducing the potential for COVID-19 transmission.[47] To facilitate the use of telehealth during the pandemic, the US Department of Health and Human Services made adjustments to telehealth requirements, including flexibility of the Health Insurance Portability and Accountability Act (HIPAA) and telehealth waivers from the CMS.[48] Bondini et al[49] conducted a rapid literature review to examine the use of telehealth to care for chronic wounds during the pandemic. Although the authors concluded that overall, evidence related to the use of telewound care remains limited, they noted that use of telewound care was associated with reduced wound-healing time.[49]

Although the evidence was inconsistent, most studies in this review reported that telewound care provided the same, if not better, outcomes than traditional in-person wound care. With increased use of telehealth modalities during the COVID-19 pandemic, more practitioners may be amenable to integrating telewound care into their practice postpandemic. Telewound could become the gold standard and blended with in-person care when complex wound care delivery is needed. Further, telehealth could be used to help patients navigate a complicated healthcare system. A telehealth patient navigation resource to assist patients requiring more complex wound care has the potential to decrease patient cost and increase patient satisfaction. Using the Project ECHO (Extension for Community Healthcare Outcomes) Model as an exemplar for providing specialty-focused education to healthcare providers in rural areas, wound care specialists at academic medical centers could provide education and consultation to interprofessional wound care teams serving rural populations.[50]

Limitations

Although this review provides information related to outcomes of telewound care, the findings are limited. Because this was a scoping review, an in-depth assessment of the quality of the studies was not performed. This review included select outcomes of telewound care, including cost, healthcare utilization, and clinical outcomes. However, other outcomes such as patient, provider, and caregiver satisfaction were not examined.

CONCLUSIONS

The onset of the COVID-19 pandemic in 2020 required healthcare providers to leverage technology to support a variety of care needs including wound care. As a result, new possibilities for transitioning typical face-to-face specialty wound care encounters to telehealth visits were realized. This increase and wide-spread adoption of telewound care may facilitate its sustained future use and sets the stage for innovation in wound care delivery, including use of blended models and strategies to educate and work with rural providers to deliver complex care. Rigorous evaluation of these models is needed to demonstrate their value. ●

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Supplemental Table. STUDIES THAT EXAMINED TELEHEALTH FOR WOUND CARE AND PROVIDED CLINICAL, HEALTHCARE, AND/OR COST OUTCOMES

Author (Year), Country	Design	Wounds	Sample (TH^a, $Comp^b$)	Intervention	Control	Clinical Outcomes	Healthcare Utilization	Cost Outcomes
Assimacopoulos et al (2008),[28] US	Retrospective; nonequivalent groups	Bacterial wound infections	N = 107 TH = 48 Com = 59	Interactive video at rural hospital with infectious disease specialists	Metropolitan hospitals with specialists on site	Days of IV antibiotic; mortality	Length of stay	–
Binder et al (2007),[30] Austria	Case series	Leg ulcers: venous and mixed	N = 16	SFT with home care nurse follow-up	None	Ulcer size, healing status	Consults visits	Transport costs
Fasterholdt et al (2018),[41] Denmark	RCT	Diabetic foot ulcers	N = 374 TH = 193 Comp = 181	SFT and telephone consult with home care nurse	Usual care	–	–	Total costs/ patient
Gamus et al (2019),[26] Israel	Retrospective; nonequivalent groups	Lower extremity ulcers	N = 650 TH = 277 Comp = 373	CVT	Usual care visits at three centers	Healing status; morality	Clinical visits	–
Garcia et al (2018),[18] US	Retrospective cohort	Burns, pediatric	N = 67 TH = 32 Comp = 35	Smartphone app (TeleBurn) for sharing images, video, instant messages, and instructional videos	Usual care	Healing time; adherence to therapy	Clinical visits	–
Hickey et al (2017),[31] US	Retrospective review	Burns	N = 31	Home TH with some SFT	None	Complications	Readmission; length of stay	Travel distance; travel cost; mileage
Hofmann-Wellenhof et al (2006),[40] Australia	Prospective, single group	Chronic leg ulcers	N = 14	SFT	None	–	Consult visits	Transport costs
Le Goff-Pronost et al (2018),[19] France	Prospective observation	Complex chronic wounds	N = 116 TH = 77 Comp = 39	Local MD and home care nurse SFT with home video	Usual care with derm	Healing time; healing status; mortality	Consults visits	Hospitalization cost, travel cost/patient
Liu et al (2017),[38] US	Retrospective review	Burns	N = 29	TH from rehab facility and acute burn hospital outpatient clinic	None	–	Clinical visits; surgical visits; avoided transports	Ambulance costs
Massman et al (1999),[42] US	Prospective observation	Burns	N = 40	CVT between clinics and burn hospital		–		Travel costs; total costs/ patient
McWilliams et al (2016),[39] Australia	Retrospective review	Burns, pediatric	N = 904	SFT and telephone consult; transfer to burn center for serious cases	None	–	Avoided bed days; avoided transfers	Avoided transfer cost/ patient
Mousa et al (2019),[29] US	RCT	Vascular surgical incisions	N = 30 TH = 16 Comp = 14	Tablet with monitoring devices (images, weight, BP)	Usual care	Infections	Readmission; clinical visits; nurse visits	–
Nguyen et al (2004),[43] US	Retrospective review	Burns	N = 294	Interactive video and SFT	None	–	–	Travel costs/ patient
Rasmussen et al (2015),[27] Denmark	RCT	Diabetic foot ulcers	N = 374 TH = 193 Comp = 181	Telephone consults	Outpatient visits	Healing status; amputations; mortality	–	–

(continues)

Supplemental Table. STUDIES THAT EXAMINED TELEHEALTH FOR WOUND CARE AND PROVIDED CLINICAL, HEALTHCARE, AND/OR COST OUTCOMES, CONTINUED

Author (Year), Country	Design	Wounds	Sample (TH[a], Comp[b])	Intervention	Control	Clinical Outcomes	Healthcare Utilization	Cost Outcomes
Ratliff & Forch (2005),[32] US	Prospective observation	Wounds in geriatric patients	N = 9	Interactive video with long term care facility and wound provider at hospital	None	Healing status		Transport cost; cost savings
Rees & Bashshur (2007),[37] US	Matched control group	Chronic wounds	TH = 19 Comp = 19	SFT with home health nurse	Matched historical group – usual care	–	ED visits; outpatient visits; hospitalizations; length of stay	Hospital costs, outpatient costs, wound care costs
Smith-Strøm et al (2018),[22] Norway	Cluster R RCT	Diabetic foot ulcers	N = 182 TH = 94 Comp = 88	Clinic TH using mobile phones with SFT	Outpatient visits	Amputation; healing status; healing time; mortality	Consult visits; community nurse visits	–
Sood et al (2016),[33] France	Retrospective database review	Pressure injuries, leg ulcers	N = 5,795	Home TH with data entry and SFT	None	Healing status	Hospitalizations; length of stay	–
Terry et al (2009),[24] US	RCT	Pressure injuries, nonhealing surgical wounds	N = 103 TH = 40 Spec = 28 Comp = 35	Home TH w/SFT and specialist consults	Usual care visits with wound care specialists; or usual care	Healing time; healing status	Length of stay; nurse visits	Total costs/ patient
Turk et al (2011),[36] Turkey	Retrospective review	Burns	N = 187	SFT, interactive video, and phone	None	Mortality	Transfers, length of stay; telehealth visits	–
Vesmarovich et al (1999),[35] US	Prospective observation	Pressure injuries	N = 8	Home TH with SFT	None	Healing status		–
Vowden & Vowden (2013),[23] United Kingdom	RCT	Any wounds in nursing home	N = 26 TH = 17 Comp = 9	Smart phone with camera, digital paper-pencil tech, and mobile phone	Usual care	Healing time; healing status; mortality	–	–
Wickström et al (2018),[20] Sweden	Prospective, nonequivalent groups	Hard-to-heal ulcers (eg, diabetic foot ulcers, pressure injuries)	N = 1,988 TH = 100 Comp = 1,888	Home TH and CVT	Usual care	Healing time	Waiting time (subset of 100 patients in comparison)	–
Wilbright et al (2004),[21] US	Nonequivalent groups	Forefoot ulcerations	N = 140 TH = 20 Comp = 120	CVT (from local facility)	Specialty clinic	Healing time; healing status	–	–
Wilkins et al (2007),[34] US	Prospective observation	Lower extremity ulcers, peripheral vascular ulcers, pressure injuries, other wounds	N = 56	SFT	None	Ulcer size	Response time for consult	–
Zarchi et al (2015),[25] US	Prospective, cluster- controlled trial	Chronic wounds of legs/feet	N = 90 TH = 50 Comp = 40	SFT with home care nurses	Home care	Wound healing; mortality	–	–

Abbreviations: Comp, comparison group; CVT, clinical video telehealth; derm, dermatologist; RCT, randomized controlled trial; SFT, store and forward; TH, telehealth.
[a]TH represents any type of telehealth utilized in the study
[b]Comp represents the comparison or control group