

Description and Utilization of Telewound Monitoring Services in Primary Care Patients with Acute Wounds in Singapore: A Retrospective Study

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ABSTRACT

OBJECTIVE: To describe an inaugural telewound monitoring service (TMS) designed for the remote monitoring of acute wounds to empower primary care patients, and identify factors associated with the utilization of the TMS.

METHODS: Retrospective data were collected from 204 patients who participated in the TMS between June 19, 2016 and August 31, 2017 and analyzed using both descriptive and multiple regression analysis.

RESULTS: The mean patient age was 27.9 years (SD, 12.4); wound area was 7.8 cm² (SD, 21.2); and duration of healing was 11.7 days (SD, 6.9). A multiple regression model based on patients' demographics and wound factors predicted which patients were likely to have more telewound sessions than face-to-face sessions. The model was statistically significant ($F = 2.093$ (11, 124), $P = .025$) with 15.7% of variance explained by the variables. An increase in age ($P = .043$) and increased days to healing ($P = .043$) were associated with a reduction in the number of telewound sessions.

CONCLUSIONS: The TMS is a valuable alternative to face-to-face wound care that enables patients with acute wounds to assume the roles of both patient and carer simultaneously. Age and healing duration are predictors for utilization of this service. Prompt attention to these predictors may improve service allocation and utilization.

KEYWORDS: acute wounds, description, primary care, telewound monitoring, utilization, wound care

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INTRODUCTION

Telemedicine is an efficient and cost-effective way to deliver health care to patients with a wide variety of medical conditions.^{1–3} It has recently been gaining traction for wound healing.^{3,4} Various forms of telemedicine are currently in practice, ranging from real-time video consultation using specialized equipment⁵ to more asynchronous forms in which wound pictures are taken and then forwarded to healthcare professionals for review.⁶ The use of telemedicine has been applied in the care of various wounds, including chronic wounds (eg, diabetic foot wounds and pressure injuries)^{7,8} and acute wounds (eg, postsurgical wounds).⁹

Current evidence suggests that telemedicine in wound care can be used for remote wound assessment, consultation with patients, and discussions among medical professionals.^{10–12} In managing acute and chronic wounds, teleconsultation among primary and tertiary care medical professionals has been widely adopted and proven feasible worldwide.^{3,8,13,14} For example, community nurses may change a wound dressing at a patient's house or primary care clinic and photograph the wounds for remote assessment by a specialist nurse or doctor,^{3,8,13,14} primary care nurses may also take and transmit wound images via the digital wound documentation tool to hospital-based wound nurses for advice on managing acute postsurgical wounds.¹⁴

There is, however, a paucity of evidence to demonstrate the efficacy of telemedicine between patients and healthcare professionals in wound care. Recent advances in mobile communication technology such as the development of smartphones with integrated cameras

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has made self-monitoring of wounds by a majority of patients⁹ more feasible and acceptable.¹⁵ It has allowed patients to capture digital images of their wound and forward these images to their healthcare providers for assessment.¹⁶

A pilot study of this form of telemedicine found that patients had positive experiences with remote wound follow-up and that the photos captured were sufficient for clinical assessment.⁹ In a Canadian trial by a group of surgeons, remote monitoring of postsurgical wounds through images uploaded by patients effectively reduced the number of in-person visits required, which was convenient for patients.¹⁷ However, these pilot trials did not specify if the patients were empowered and educated to change their wound dressings at home.

Self-management of wounds can lead to numerous benefits for patients ranging from reduced healthcare costs to increased emotional wellbeing.¹⁸ A study in the authors' local Asian context found that patients who had simple acute wounds were receptive to dressing their wounds themselves at home and having their wounds followed up by a nurse remotely via telecommunication.¹⁹

This study aims to describe the inaugural use of a telewound monitoring service (TMS) in primary care in Singapore by patients and nurses for acute wound management and identify patient- and wound-related factors associated with the utilization of this service.

METHODS

A TMS was initiated in a large primary healthcare setting in Singapore in 2016. This novel format aims to help patients with acute wounds learn and change wound dressings themselves at home, while nurses monitor and appraise their wound healing progress remotely.

The TMS is an asynchronous form of telemedicine in which patients take their wound images using digital devices (camera or smartphone) during wound dressing changes. Digital wound images are subsequently forwarded to nurses via email for remote wound monitoring and follow-up telephone calls for wound assessment without conventional face-to-face visits. Wound care advice is given to patients based on assessment and comparisons of wound images obtained by nurses and patients. The predesigned screening questions, which are part of patient wound care education, are used to assess potential wound infection during follow-up telewound calls. For example, some questions for assessment of potential wound infection include: "Have you experienced any increasing pain at wound site?" "Do you have any increase in wound discharge?" "Are there any changes to the skin surrounding your wound such as increased redness, warmth or hardening of skin around the wound?" or "Do you have a fever?"

A face-to-face wound care assessment by a nurse in the clinic is conducted after every two telewound monitoring

sessions to ensure that wound healing follows a normal trajectory. The TMS is terminated in the event of deterioration of wound healing or by patient request. Otherwise, the telewound monitoring ceases when patients' wounds heal. The Figure shows the process of the TMS.

The eligibility criteria for the TMS includes patients with noninfected wounds with low or no risk of wound deterioration (abrasions, superficial lacerations, surgical wounds healing by primary/secondary intention, stage 1 and 2 pressure injuries and stable venous leg ulcers). Instead of receiving their regular follow-up care for face-to-face wound dressing changes at the facility, all eligible patients requiring frequent follow-up wound care are encouraged to participate in the TMS and are given the opportunity to take charge of their wound healing with support and guidance from their healthcare professionals. Written consent is obtained from patients upon enrollment in the TMS.

Patients and Variables

In this retrospective study, the study population was all patients who participated in the TMS in the primary care setting. Consecutive data for all participating patients in the primary care setting were retrieved retrospectively from the telewound care database from the inception date of the service (June 19, 2016) to August 30, 2017. Data on patients considered eligible for the TMS but who refused to enroll were not available from the database. Data collected included age, ethnicity, sex, location of the wound, type of wound, number of wound products used, wound area, number of face-to-face visits, number of telewound monitoring sessions, and days to heal.

Institutional approval was obtained from Nursing Services to conduct this research. Ethical approval was obtained from the National Healthcare Group Domain Specific Review Board (NHG DSRB Ref: 2017/00943).

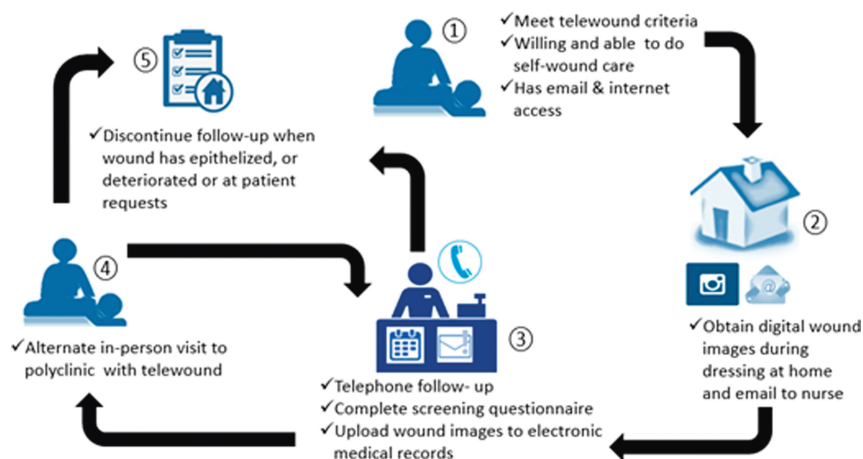
Data Analysis

Investigators determined that for multiple regression analysis to predict the wound healing rate with up to 17 independent predictors, assuming 5% significance, 80% power with moderate effect sizes, and 10% incomplete data,²⁰ the minimum required sample size for analysis was 205. Data were analyzed using SPSS version 23. Descriptive statistics were used to analyze the demographic data. Frequencies and percentages were used to show the proportions of subgroups within a group. Means, SDs, and ranges were used to describe and tabulate variables. Multiple regression analysis was used to predict factors associated with wound healing rate and usage of the TMS.

RESULTS

The researchers reviewed the electronic medical records of 520 eligible patients. They included 205

Figure. TELEWOUND MONITORING SERVICE PROCESS



patients in the study and ultimately 204 patients' data were analyzed (1 patient was missing data). Of these, the majority were Chinese (62.7%), men (69.8%), and had wounds on their extremities (84.4%). The mean age of patients who used the TMS was 27.9 (SD, 12.4) years old, the average time needed for wound healing was 11.7 days (SD, 6.9), and the mean wound area was 7.8 cm² (SD, 21.2). Table 1 shows the results of descriptive analysis.

Differences in Days to Healing

There was no significant difference in the number of telewound sessions compared with face-to-face sessions based on sex, ethnicity, location of wound, type of wound, age, or wound area. There were significant differences in the frequency of telewound sessions versus face to face appointments by the number of wound products and days to healing: patients with two wound products required significantly more days to heal than patients with no wound products or one wound product ($F = 4.164$, degrees of freedom = 2 and 190, $P = .017$).

Predictors for Patients by Number of Telewound Sessions

Multiple regression analysis was conducted to predict patients' number of sessions in the telewound service based on age, sex, wound location, type of wound, wound area, number of wound products used, and days to healing. The model was statistically significant ($F = 11.130$ (11, 124), $P < .001$) with 49.7% of the variances explained by the variables. With each 10-day increase in healing, the number of telewound sessions increased by one session ($B = 0.105$; $P < .001$). That is, more telewound sessions are needed for wounds that take longer to heal.

Predictors for Patients by Number of Face-to-Face Sessions

Multiple regression analysis was conducted to predict patients' number of face-to-face sessions based on age,

sex, wound location, type of wound, wound area, number of wound products used, and days to healing. The model was also statistically significant ($F = 7.503$ (19.8, 2.6), $P < .001$) with 40% of the variance explained by the variables. With each 30-year increase in age, the number of face-to-face sessions increased by one session ($B = 0.033$; $P = .009$) and with each 20-day increase in healing, the number of face-to-face sessions increased by three sessions ($B = 0.157$; $P < .001$). That is, more face-to-face sessions are needed for patients who are more advanced in age and for wounds that take longer to heal.

Predictors for More Telewound Sessions than Face-to-Face Visits in the Telewound Service

Multiple regression analysis was conducted to predict patients with more telewound sessions than face-to-face visits based on age, sex, wound location, type of wound, wound area, number of wound products used, and days to healing. The model was statistically significant ($F = 2.093$ (11, 124), $P = .025$) with 15.7% of the variance explained by the variables. With each 30-year increase in age, the number of telewound sessions decreased by one session ($B = -0.037$; $P = .043$) compared with face-to-face visits; similarly, with each 20-day increase in healing, the number of telewound sessions decreased by one session ($B = -0.052$; $P = .043$) compared with face-to-face visits.

DISCUSSION

In the present study, participants of Chinese ethnicity made up nearly two-thirds of the study population (62.9%) and less than one-third of the total study population were women (30.2%). The findings align with a recent study conducted in Singapore in a chronic wound population in primary care.²¹ The mean wound area in the present study (7.8 ± 21.2 cm²) was comparable to the findings of a recent study conducted in Singapore on

**Table. RESULTS OF DESCRIPTIVE ANALYSIS**

Variable (N = 204)	n (%) or Mean (SD)
Age, y	27.9 (12.4)
Sex	
Male	143 (69.8)
Female	61 (30.2)
Race	
Chinese	128 (62.7)
Malay	57 (27.9)
Indian	15 (7.4)
Other	4 (2.0)
Wound location	
Upper limbs (shoulder and beyond)	39 (19.0)
Axilla	4 (2.0)
Lower limbs (knee and beyond)	134 (65.4)
Back of the chest	6 (2.9)
Front chest	3 (1.5)
Buttock	2 (1.0)
Abdominal	5 (2.4)
Front hip	4 (2.0)
Face and neck	7 (3.4)
Wound type	
Abrasion	65 (31.7)
Laceration	13 (6.3)
Burns	6 (2.9)
Postsurgical wound healing, primary intention	59 (28.8)
Postsurgical wound healing, secondary intention	61 (29.8)
No. of wound products used	
0	21 (10.3)
1	171 (84.3)
>1	11 (5.4)
Wound area, cm²	7.8 (21.2)
Healing time, d	11.7 (6.9)

patients with diabetic foot ulcer ($7.0 \pm 12.5 \text{ cm}^2$).²² However, the mean age of the participants (27.9 ± 12.4 years) in the present study was much younger compared with the reported age of the patients with chronic wounds (61.2 ± 4.6 years) and diabetic foot ulcers (66.3 ± 11.3 years).^{21,22}

The mean age of the patients who participated in the TMS was in their twenties. This concurs with a large online survey conducted in Japan during the pandemic that found younger individuals generally have increased use of telemedicine compared with older individuals.²³ This could be attributed to the skillset of the Millennial generation (defined by the Pew Research as individuals born between 1981 and 1996), who are typically more adept in using smartphone and internet technology than previous generations.²⁴ Millennials may be

more confident in adopting information communication technology (ICT)²⁵ and as such might be more comfortable in using their smart devices to capture their wound images and participate in wound self-care.

An increase in number of days to heal leads to a significant increase in telewound monitoring sessions. This could be attributed to the need for more dressing changes over time.^{26,27} That is, an increase in days to heal leads to more telewound monitoring sessions as the number of dressing changes increase until the wound has completely healed.

Investigators found that patients who required two types of wound products had a longer healing time than those who required only one product type or no wound products. Because the choice of wound dressing is based on the assessment of the wound condition and environment, patients with multiple wounds that have different milieu would require different dressing products to optimize healing.²⁸ The most plausible explanation for this finding is that multiple wounds require multiple types of wound dressing products, thereby taking longer to heal.

Age was the predictor for fewer telewound monitoring sessions versus face-to-face visits and an increase in age correlated with an increase in overall face-to-face visits. Older adults might lack prior exposure to ICT, feel apprehensive about new technology, or have difficulty keeping up with ICT.²⁹ A recent study conducted in the US found that older adults (older than 65 years) were more likely to report not knowing how to use teleconferencing compared with respondents who were younger (ages 21 to 40 years).³⁰

Further, changing wound dressings at home requires patients to understand the nature of their wounds and to recognize when further follow up at the clinic is necessary. This may be a struggle for older adults because they tend to be frail,³¹ face challenges such as difficulty using technology, have hearing problems, struggle with hands-on self-examinations,³² or lack access to a caregiver to assist them with technology,³³ reducing the success of wound self-management.

Current literature found that age-related skin changes impair wound healing,³⁴ and concurrent comorbidities contribute most to the development of nonhealing wounds in the older adult.³⁴ Further, slower healing increases the risk of infection and the likelihood of chronicity,³⁵ also leading to more complex wound management in older adults.³¹ This, coupled with older adults' reluctance to use ICT in healthcare, could lead to a preference for face-to-face dressing sessions over the TMS.

An increase in days to healing predicted fewer telewound monitoring sessions compared with face-to-face visits. Prior literature suggests that wounds with local infection might result in delayed healing,³⁵ requiring comprehensive

assessment and treatment (ie, wound bed preparation) by a trained healthcare professional.³⁶ This could be a possible reason for the decreased number of telewound monitoring sessions compared with face-to-face visits.

Overall, the mean healing time for acute wounds in the present study aligns with the current literature, further establishing that the healing of acute surgical wounds in healthy individuals is usually complete within 2 to 4 weeks³⁷ and the timing of suture/staples removal of most acute surgical wounds is less than 2 weeks.³⁸ This highlights an important aspect for self-care of acute wounds using telemedicine, which could possibly evoke the full potential of patient involvement in self-wound management, especially in such a short timeframe. In addition, although the ultimate healing time of an acute wound is multifactorial, the healing time of uncomplicated acute wounds was comparable between the TMS and face-to-face visits.

This new wound care model allows healthcare professionals to communicate with patients to provide direct care and advice with image assessment to aid in consultation. Although synchronous video consultations have been implemented in wound care, a scoping review of wound telemedicine during the COVID-19 pandemic found that wound video consultations are often implemented together with an on-site healthcare professional and patients often encounter barriers to entry such as cost and complexity of service.³⁹ The review also found that telephone wound consultations (similar to the model in the present study) were more acceptable to patients.³⁹

Limitations

Data collection was based on retrospective review of the telewound monitoring registry; some desired variables were not recorded, such as the characteristics of patients who were considered eligible for but refused to enroll in the TMS, factors associated with wound healing (ie, tobacco use, diabetes status, nutrition status, and medication history), and patient satisfaction surveys. Patient self-assessment questionnaires also could be improved to include objective data such as body temperature and a pain scale. Finally, the authors did not evaluate whether the quality of wound images taken by patients using their personal devices was adequate for clinicians to perform wound assessment. Future research is recommended in these areas.

CONCLUSIONS

Telewound monitoring is a valuable alternative to face-to-face wound care service and has the potential to engage more patients with acute wounds in their own wound care. Although this new model was less readily adopted by those more advanced in age, results from this study suggest that the TMS is a reasonable alternative to respond

to wound care service demand in primary care without compromising clinical outcomes. More research and development is needed to further improve this care modality through incorporating more advanced artificial intelligence and other new technology to engage more patients with various wounds regardless of patient demographics or wound characteristics. Future prospective research on understanding the barriers to technology adoption and incorporating age-appropriate educational support to increase telemedicine use among older adults is recommended. ●

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