The use of an imaging application in chronic wound management among nursing home patients: a pilot study

Key words:

- *Artificial Intelligence*
- *Nursing home*
- *Teledermatology*
- *Ulcers*
- *Wound imaging*
- *Wound management*

Aim: Our study explores the use of CARES4WOUNDS (C4W) application to manage chronic wounds in nursing homes over a two-month period. **Methods**: The intervention group was managed using C4W while the control group was managed by wound care nurses. **Results**: We recruited 9 patients to the pilot study, however, two were excluded after being transferred to hospital for unrelated reasons. All patients showed improvement in Falanga wound scores. The average consultation time and travel costs were lower in the intervention group. The average system usability scale score was 51.6. **Conclusion**: We want to use these findings to plan a larger cost-benefit analysis of C4W in chronic wound management.

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Chronic wounds are defined as wounds where healing is impaired and does not occur in a timely and organised manner due to a variety of reasons, including inadequate vascularity and innervation (Golinko et al, 2009). There is a lack of consensus on the time-frame that differentiates chronic and acute wounds (Kyaw et al, 2018).Chronic wounds arise from various aetiologies, including pressure distribution abnormalities, venous insufficiency, ischaemia, diabetes, and trauma or surgery.

Globally, the pooled prevalence of chronic wounds is 2.21 per 1000 population (Martinengo et al, 2019). Data from tertiary hospitals and public primary care clinics in Singapore has shown an increasing prevalence of chronic wounds. A recent study recorded a 95.1% increase in wound-related hospital admissions from 2013 to 2017, contributed to by increases in the prevalence of neuro-ischaemic ulcers and pressure ulcers (PU) (Lo et al, 2020). This has translated to an increased clinical and economic burden on the Singaporean healthcare system. In 2017 alone, the gross healthcare cost of chronic wounds in a single tertiary hospital in Singapore totalled SGD (Singapore dollars) $293 million (Lo et al, 2020). Another study conducted in Singapore estimated the gross direct cost of chronic wounds to each patient to be SGD $9532 (Tan et al, 2016).

Chronic wounds are prevalent in nursing homes, where patients are at higher risk of developing chronic wounds in view of their multiple comorbidities and reduced mobility. A study conducted in a teriary hospital in Singapore found that 15% of patients admitted for category III and IV PUs were nursing home residents (Graves et al, 2020). Although nursing home staff are competent in basic wound care and dressing, they rely on wound assessments by specially-trained wound nurses and doctors, who make decisions on the types of dressings required or need for further wound management like antibiotics, debridement or specialised dressings, such as those applying compression or negative pressure wound therapy. While there have been increasing efforts to train nursing home staff on wound care techniques and practices, there are currently no nursing homes in Singapore with wound care teams that have such expertise. Therefore, frequent reviews by wound clinicians are often required, which is time-consuming and expensive, increasing the strain on the healthcare system.

Technology has made rapid advancements, allowing for important applications in healthcare to improve access and efficiency. The use of imaging technology in wound management has been increasingly promoted in recent years, and chronic wound

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management is another opportunity to explore the potential of telemedicine (Jones et al, 2004).

We evaluate the use of the "CARES4WOUNDS (C4W)" (Tetsuyu Homecare) in chronic wound management in nursing homes. C4W is a wound care imaging and artificial intelligence system that assists in contactless wound assessment. It images wounds, measures wound dimensions, and classifies wound beds based on degree of re-epithelialisation, granulation, necrosis and amount of slough present. The algorithm then trends the stored data on the wound bed and wound dimensions to detect early wound infections or poorly healing wounds. Based on this, the algorithm provides suggestions on wound management such as types of dressings and wound cleansing solutions, additional skin products, and the need for debridement. The stored data can also be assessed remotely so that wound specialists who are not on-site can provide their suggestions on wound management. C4W demonstrated excellent intra-rater and inter-rater reliability in wound measurements in a recent local study (Chan et al, 2021).

Aims

Our aim is to see if the C4W application can act as an adjunct in the management of chronic wounds in nursing homes, reducing the need for frequent visits by wound clinicians, while maintaining similar quality of wound care. This can help with time and cost savings related to consultations by the wound specialists. Our team launched a trial of the C4W application in a small population of nursing home residents in Singapore as a pilot study evaluating its use in the management of chronic wounds in nursing homes.

Materials and methods

This is a pilot study on the use of the C4W application to aid chronic wound management in nursing homes, where nursing care is limited and staff have less experience treating chronic wounds.

Patients with chronic wounds were recruited from two nursing homes in Singapore. Patients were excluded from this study if they were <18 years old, medically unstable, had a life expectancy of less than 2 months, or had complicated wounds requiring advanced wound care in an acute hospital.

The study participants in one nursing home were placed in the intervention group, while the study participants in the other nursing home were placed in the control group. Wounds in the control group were managed conventionally based on the current standard in the nursing home, with weekly assessments by a wound clinician who provided recommendations on wound management, such as types and frequency of wound dressing, and need for further intervention like debridement.

In the intervention group, visits by the specialised wound clinician were reduced by half (once in two weeks), and the C4W application was used for wound assessment and to provide recommendations on management. Through remote monitoring, the wound clinician reviewed wound reports and provided guidance. The same wound clinician assessed the wounds in both the intervention and control groups, and the wounds were dressed regularly by the nursing home staff.

A separate wound clinician then collected data to assess differences in wound healing between the two groups. Clinical photographs of the wounds were also taken at each review. The time taken for wound assessment, wound dressing change, documentation, wound clinician consultation, and travel time to the nursing homes were also recorded. The study was conducted over two months from November 2020 to January 2021.

Usability of the C4W application was assessed using the system usability scale (SUS). The SUS is a 10-item questionnaire that is administered to users of an application to assess its usability. The SUS was chosen for our pilot study as it is easy to administer and can be used reliably in a small sample size (Tullis and Stetson, 2004; Bangor et al, 2008; Lewis and Sauro, 2009). There were 14 nursing home staff in the intervention group were asked to fill out the SUS questionnaire following completion of the pilot study to evaluate the C4W application.

Results

While our team had aimed to include 30 patients in the pilot study, we were only able to recruit 9 patients due to limitations as a result of the COVID-19 pandemic. There were 2 patients who were subsequently transferred back to acute hospitals during the study for reasons unrelated to their wounds, and were thus excluded. There were 5 patients in the intervention group and 2 patients in the control group.

Wound healing

Out of the 5 patients in the intervention group, 2 patients had their wounds completely healed by the end of the study, the other

Table I. Summary of wound healing, cost and time savings and usability scores

	Intervention group	Control group
	Mean ± standard deviation	Mean ± standard deviation
Rate of improvement in Falanga score (%)	8.7±7.2	4.2 ± 3.5
Time spent per patient during each visit by wound clinician (minutes)	48.5±11.4	61.4±9.7
Time spent per patient during each wound inspection and dressing change by nursing home staff (minutes)	27.2±9.9	28.8±7.6
Consultation cost per patient during each review (SGD)	51.6±14.2	-

3 patients saw an increase in the size of their wounds. Both patients in the control group had smaller wounds by the end of the study. While reduction in the size of the wounds is a good gauge of wound healing, measurement of the exact improvement in size is difficult as the area and volume of wounds tend to be over- or under-estimated during calculation based on the length, breadth, and depth of the wounds. The Falanga wound bed score was therefore also used in the assessment of wound healing. The Falanga score is a clinical tool used in the classification of wound beds based on wound granulation, amount of exudate and oedema, and the state of the epidermis. It is not only useful in the assessment of wounds, but also aids in predicting the ultimate healing outcome of the wound. Each parameter assessed is given a score, with each wound having a potential maximum score of 16. For each unit increase, there is a 22.8% increase in the chance of healing (Falanga et al, 2006). The Falanga score relies mainly on visual inspection, and is a suitable non-invasive visual tool for assessing wound healing outcomes in patients receiving telemedicine wound care. All 7 patients in our pilot study saw improvement in their Falanga scores by the end of the 2-month period. In the intervention group, the average rate of improvement in Falanga score was 8.72% per week. This was higher than the average improvement rate of 4.17% per week in the control group *(Table I)*.

Time spent on wound care

The average time spent by nursing home staff during regular wound inspection and dressing was similar between the intervention group (mean: 27.3 minutes) and the control group (mean: 28.8 minutes). In the group using the C4W application, our study protocol reduced the number of wound clinician reviews by half, allowing the wound clinician to spend less time on travel. The wound clinician spent an average of 131 minutes reviewing each patient in the intervention group over the course of the 2-month study. In the control group, the average time spent by the wound clinician on each patient was 270 minutes. The average total consultancy time, consisting of time spent on travel and on consultation for each patient, was shorter in the intervention group, 185 minutes, than in the control group, 491.5 minutes *(Table I)*.

Cost comparison

With fewer visits required by the wound clinicians in the intervention group, the cost of travel was lower in the intervention group, with a total of SGD $90.40 incurred by the intervention group over the 2-month pilot study. This was two-thirds the total cost of SGD $284.35 incurred by the control group. The shorter time spent by the wound clinician on each patient in the intervention group also translated to cost-savings for the nursing homes. The average consultancy cost incurred per patient in the intervention group was SGD $455.56 over the 2-month period, less than half the average cost of SGD $1175.78 incurred per patient in the control group. Combining consultancy and travel costs, the average cost incurred per patient in the intervention group was SGD $493.65, less than 40% of the SGD $1317.95 incurred per patient in the control group.

Usability of application

The SUS tool was administered to the 14 nursing home staff who used the C4W application during wound assessment in the intervention group. The average SUS score for the C4W application was 51.6. SUS scores range between 0–100, and 68 is considered the average score, with higher scores indicating higher usability (Brooke, 1996; Sauro and Lewis, 2012). Individual feedback was gathered from each staff regarding their concerns in using the

C4W application. Feedback from the nursing home staff clustered around several issues. A common challenge was in using the application to photograph the wound during assessment. The application had difficulty accurately demarcating the wound borders in patients with darker skin tones. Staff reported having to manually demarcate the wound borders on the application instead. Staff also faced technical issues with the application stalling or requiring frequent re-booting. There were problems with connectivity, as the application relies on wireless internet connectivity to access its cloud-based system. Finally, the C4W application also requires the nursing staff to be familiar with a variety of wound care products. After making an assessment of the wound, the application suggests suitable types of wound dressings that can be used. The staff was used to wound clinicians giving specific instructions on which dressings to use, and were less familiar with the generic wound product categories suggested by the application.

Discussion

Chronic wounds contribute substantial clinical and economic burden to the healthcare system. International studies have found that about 70–80% of wounds are managed in the community setting, largely by nurses (Drew et al, 2007; Lindholm and Searle, 2016). As tertiary hospitals continuously aim to shorten length of hospitalisation, community hospitals and nursing homes may end up managing wounds of increasing complexity.

Singapore's aging population and increasing prevalence of diabetes may also result in a higher incidence of chronic wounds as time progresses. The prevalence of diabetes in Singapore is one of the highest among the South East Asian countries at a rate of 13.7% compared with the average of 8.5% (International Diabetes Federation, 2017). The latest National Health Survey conducted in 2020 showed a rise in the prevalence of diabetes among Singaporeans, from 8.6% in 2010 to 9.5% in 2020. This was attributed to population ageing after age standardisation (Epidemiology & Disease Control Division, 2020). In a recent study on chronic wounds in Singapore, the majority of wounds were diabetic foot ulcers, and a significant bulk of these patients were elderly with multiple comorbidities (Lo et al 2020). This has resulted in an average of four diabetes-related lower limb amputations a day in Singapore (Ang et al, 2017). An increasing prevalence of chronic wounds will also lead to a greater strain on the wound care nurses who are managing a large proportion of these chronic wounds in the community.

Safety in wound management

Although the wounds in the intervention group seemed to fare better in terms of the Falanga wound bed score, we were unable to draw any statistically significant conclusion on the effect of the C4W application on wound healing due to our small study population. Conversely, our study did not identify any adverse wound outcome or complication resulting from the use of the application in wound management.

International studies reviewing the use of imaging technology or telemedicine in wound management have also had conflicting conclusions, (Steventon et al, 2012; Rasmussen et al, 2015) in part because such studies are difficult to conduct. A systematic review in 2014 of studies comparing telemedicine with traditional care in patients with leg ulcers found that the evidence was inconclusive, with poor methodological quality among the studies (Nordheim et al 2014).

Based on our pilot study, the Falanga wound bed score appears to be a useful measure of wound healing outcomes, in addition to measurement of wound parameters. A future study with a larger study population is required to better evaluate wound healing outcomes of using wound imaging technologies like the C4W application in chronic wound management. It would also be beneficial to collect additional data on the aetiology of the various chronic wounds included in the study.

Cost-effectiveness

The C4W application can potentially contribute to time and resource savings in chronic wound management by reducing the number of wound nurse visits required. In our study, the number of wound clinician visits was safely reduced by half in the group using the C4W application without any adverse outcomes or complications. However, a further study on a larger population is required to adequately evaluate the cost-effectiveness of the C4W application.

This study has not shown substantial time savings for the nursing home staff in the management of chronic wounds. There was no meaningful difference in the time required by nursing home staff to inspect, dress and treat wounds between the control and intervention group. This may be partly attributed to

difficulties with using the application reported by the nursing home staff. These difficulties may have caused the wound inspection and dressing process to become more time-consuming, negating the time saved by the application in documentation and trending of data.

Usability

Based on our results, the C4W application scored poorly on the SUS, with the average score achieved by the C4W application being only 51.6. (Sauro et al, 2011) studied more than 5000 SUS evaluations and found the average score to be 68 based on percentile rankings of all the SUS scores. Our results found that the C4W application fared poorly in the questions surveying the complexity and consistency of the application. This correlated with individual feedback received regarding technical difficulties in loading data on the application. There was also feedback on the inconsistency of the application performance in assessing wounds that were small and wounds of darker-skinned patients. Similar issues were raised in a recent study by Chan et al, (2021), where manual adjustments to wound measurements had to be made, particularly when there was poor colour contrast between the wound and underlying skin tone, irregular contours underlying the wound (e.g. bony prominences), or small size of wounds (<1cm). In spite of this, some of the nursing home staff surveyed were interested in how the application could potentially improve the ease of wound assessment and documentation. We believe that the C4W application can be a useful adjunct in the management of chronic wounds, if the necessary adjustments are made to improve the accuracy and reliability of wound assessment. The efficacy of the application also depends on how well users are trained to use it, and if they are using the application appropriately as intended. User education is also crucial to ensure familiarity with wound products available, since the application can only suggest types of wound dressing but not specific brands.

Imaging technology like the C4W application has the potential to be a useful adjunct in managing chronic wounds, provided adequate training is provided in using the application efficiently, and improvements to the application are made based on user feedback. Wound care nurses and specialists will continue to lead the management of chronic wounds, but technology can be useful in streamlining their role. Our study also highlighted the need for an effective wound management protocol should such wound imaging applications be used in wound management.

Limitations

As this pilot study was conducted just as the COVID-19 pandemic was building up, strict measures reducing access resulted in difficulty in recruiting nursing homes and patients for the study. Despite initial plans to include 30 patients in the study, we were only able to recruit 9 patients who fit the inclusion criteria. Furthermore, changes in nursing home operations restricted our study period to a duration of 2 months. As one nursing home was chosen to be the intervention group while the other was the control group, it was not possible to blind the wound clinician assessing the wounds. A larger-scale study involving more nursing homes and a larger study population will allow our team to adequately evaluate the use of the C4W application in chronic wound management. It would be useful to collect additional data on the various aetiologies of the chronic wounds, as this may affect the outcomes of wound healing and time required for dressings. Further analysis can also focus on the cost-effectiveness of the application in terms of time saved in wound assessment and documentation by nursing home staff, as well as time spent on wound consultations by the wound clinicians.

Conclusions

Applications like C4W have the potential to be a useful tool in the management of chronic wounds. By trending data about the wound parameters and allowing the progress of the wound to be monitored remotely, the application can help to reduce the need for frequent in-person wound clinician reviews. This is especially beneficially given that specially-trained wound nurses will be required to manage more and more chronic wounds in the community setting. This pilot study allowed our team to better understand the issues faced by staff using the C4W application in clinical wound care. With subsequent improvements in the application for better accuracy and consistency of wound assessment, C4W may help to cut down the time required for wound inspections and documentation. This pilot study also provides valuable information to guide the planning of a larger trial to evaluate the time and cost savings as well as wound outcomes of using the C4W application in

chronic wound management. The COVID-19 pandemic has emphasised the role of innovative technology like these types of applications in improving continuity of care. While it is unlikely that technology can entirely replace in-person review by wound clinicians, it can be a useful adjunct in providing quality chronic wound management to the wider population. WAS

Conflicts of Interest: There were no conflict of interests as this study was not sponsored. However, the Cares4wounds application was loaned from Tetsuyu Healthcare Holdings for the purpose of the trial.

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