RAPID EVIDENCE SUMMARY

DELIVER
Research for better healthcare closer to home

How is technology being used for remote monitoring of diabetic foot ulcers?

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Background

Diabetic foot ulcers (DFUs) affect up to 34% of people with diabetes, leading to significant morbidity, healthcare costs, and reduced quality of life.[1] Up to one in five patients with DFU require amputation, and rates of amputation in Australia are up to 10 times higher in patients residing in non-metro area.[2] Recurrence of ulcers is very high.[3] The complex multifactorial pathogenesis of DFU makes early detection and monitoring challenging. However, the potential for digital technology is significant, because the multifactorial aetiology can be monitored via different technology in several ways.[4] For example, the prevention and treatment of DFU via wound healing, diet, exercise, and pressure offloading, can be readily remotely monitored via technology. The aim of this evidence summary is to answer: How is technology being used for remote monitoring of diabetic foot ulcers?

Literature search

How did we answer this question?

This evidence summary uses a non-systematic approach, rapidly reviewing the most relevant, recent, and high-quality evidence to answer this question. The evidence is reviewed alongside one academic expert and one content expert, to produce a brief evidence summary that is "good enough" to inform health services of relevant topics.[5] This document alone is not sufficient to solely inform decision-making.

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Findings

What types of technologies are being used?

A very wide range of remote monitoring technologies have been developed and tested for prevention and treatment of diabetic foot ulcers,[4,6] with technologies falling largely under three categories:

- The most established is **telehealth**, involving remote consultation combined with image sharing for prevention and treatment. Recent advances in this area include more sophisticated imaging technology, including via smartphones.
- A second area of innovation relates to **modelling** to improve detection and prediction of DFU, as well as healing. For example, advanced computational modelling is being developed to model plantar pressure. Future applications of this would involve personalised treatment plans to modify plantar pressure. In addition, artificial intelligence/machine learning models are being developed to support automated wound classification, prediction of healing, risk stratification, and smart image technology. All of these have potential to replace or augment the usual care approach of visual inspection, potentially making it less time and resource intensive .
- A third area of innovation relates to **"smart" technology**, or hardware that use sensors, connectivity, and software to gather, analyse, and act on data. Examples include smart dressings with sensors to monitor healing, smart insoles for pressure monitoring, and smart socks for temperature monitoring, as well as sensors to monitor blood glucose levels, acceleration, humidity, and other factors that impact diabetic foot ulcer prevention and treatment.

What is the evidence supporting their usage?

Most of the available evidence for remote monitoring in DFU prevention and treatment is in **telehealth combined with digital image sharing**. A systematic review of all available studies showed that this type of technology resulted in significantly reduced amputation rates, but no differences compared with controls in sustained ulcer healing rates or mortality.[6] Overall, telehealth was most effective when used to supplement rather than replace face-to-face consultations. Additional benefits included more efficient data collection, shorter consultation times, and fewer hospital appointments required. Research on the patient experience has shown that patients have high adherence to capturing and uploading images. Studies found strong agreement between photograph-based and in-person ulcer assessments, though mobile phone-based assessments showed lower levels of agreement when compared with in-person assessments than tablets.

For newer types of technology, while there are many studies in thousands of participants, most of the evidence is in relation to the development of the **sensor technology**. Clinical effectiveness testing of artificial intelligence/machine learning tools and smart technology for DFU prevention and treatment remains limited, and the translation of these technologies into clinical care faces significant challenges relating to data and patient experience. For example, the data that is collected by sensors is restricted to surface level measurements, and most can't detect deeper indicators, like poor blood flow or other physiological features of wound healing.[4] Moreover, the data can be challenging to interpret, and many sensors don't connect with existing clinical infrastructure. Research on the patient experience has shown smart socks may have higher adherence than smart insoles, smart insoles are restrictive to patients, making people less likely to wear them.[4] Cost, size, privacy, and other design issues also remain challenging.

Most of the evidence focuses on a single component of DFU care and single modality of technology, rather than multi-component/multi-modality approaches.[4] There remains ample opportunity for developing much larger, more comprehensive, and integrated remote monitoring and decision support systems with the potential to capture and integrate data from multiple sources.[6] In addition, the models of care were predominately nurse-led or wound specialist led. Alternative models of care may result in different clinical, cost, and experience outcomes. Finally, very few studies have addressed the cost-effectiveness of any remote monitoring for DFU.

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What does this mean for health services?

There is evidence that remote monitoring using telehealth and image sharing for DFU is effective in reducing amputation. Given that amputation in rural and regional areas can be ten times higher than metro areas, this model of care may be particularly useful in such settings.

There are promising signals that novel remote monitoring technology, such as artificial intelligence/machine learning and sensors will lead to remote, personalised prevention and treatment for DFU, but these tools are not yet at the clinical delivery stage in Australia. Larger-scale validation studies with longer follow-up periods to establish the real-world effectiveness and cost-effectiveness are needed.

Emerging Australian Guidelines for the prevention of DFU highlight the potential for technology to be used, once validated and available in Australia,[3] but note that acceptability and adherence to some technology, such as sensors in shoes and socks, will need to be explored in Australian populations where climate and cultural attitudes are different.

In the future, health services will need to balance the benefits of these novel remote monitoring technologies with practical deployment considerations including cost, maintenance, and staff training requirements. Additionally, significant data issues will need to be addressed, such as ensuring ability to capture large amounts of patient data; transfer of data between the patient and relevant providers; and the ease of storing, accessing, and sharing the data, particularly in models of care that need to share data between community, outpatient, primary, and hospital settings.[6]

Limitations

- There remains limited evidence of clinical effectiveness of these new technologies.
- The data is primarily from the US and to a lesser extent, Europe and Asia which has a different healthcare system context, with no data from Australian settings.

References

1. Bergin SM, Gurr JM, Allard BP, et al. Australian Diabetes Foot Network: management of diabetes-related foot ulceration--a clinical update. *Medical Journal of Australia*. 2012;197(4)
2. Australian Commission on Safety and Quality in Health Care. *Australian Atlas of Healthcare Variation.* . 2015.
3. Kaminski MR, Golledge J, Lasschuit JW, et al. Australian guideline on prevention of foot ulceration: part of the 2021 Australian evidence-based guidelines for diabetes-related foot disease. *Journal of foot and ankle research*. 2022;15(1):53.
4. Lazarus J, Cioroianu I, Ehrhardt B, et al. Data-driven digital health technologies in the remote clinical care of diabetic foot ulcers: a scoping review. *Frontiers in clinical diabetes and healthcare*. 2023;4:1212182.
5. Norman G, Wilson P, Dumville J, Bower P, Cullum N. Rapid evidence synthesis to enable innovation and adoption in health and social care. *Systematic Reviews*. 2022;11(1):250.
6. Drovandi A, Wong S, Seng L, et al. Remotely delivered monitoring and management of diabetes-related foot disease: an overview of systematic reviews. *Journal of Diabetes Science and Technology*. 2023;17(1):59-69.

The DELIVER Research Project:

- Identifies what the people and healthcare providers of western Victoria need most in terms of home-based healthcare services
- Designs and tests the best way to deliver these services, so that home-based healthcare services will continue to grow and improve across the region and beyond
- Supports the growth of research in western Victoria, so that future research findings can quickly be translated to improvements in healthcare

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