Title: Innovation in wound care - A critical discussion of what we can learn from low-resource settings

Abstract:

Frugal innovation is currently a common philosophy in low-income settings due to limited access to resources. However, with both the increasing prevalence and clinical acuity of patients with wounds in the UK it is essential that alongside innovation such as harnessing cutting-edge new technologies, frugal innovation is also pursued. This may improve both economic efficiency and patient outcomes. Frugal innovations were adopted throughout the COVID-19 pandemic and included opportunistic solutions such as video conferencing services to run clinics. However, there are many more opportunities for frugal innovation in wound care, including the use of smartphone technology which is already accessible to 99.5% of UK clinicians caring for wounds, or the simplification of wound assessment processes using pulse oximeters as an alternative to dopplers as in the Lanarkshire Oximetry Index. This article explores what frugal innovation is and how it could improve UK wound services and calls on clinicians working in wound care to consider their access to existing resources which may not currently be considered useful for wound care processes and explore how these could be used to improve clinical outcomes.

Keywords: Frugal innovation, wound care, Low to Medium Income Countries, technology

Authors:

Dr Melanie Stephens, PhD, RGN, Senior Lecturer in Adult Nursing, School of Health and Society, Mary Seacole Building, University of Salford, UK

Matthew Wynn, MSc, RN Adult, Lecturer in Adult Nursing, School of Health and Society, Mary Seacole Building, University of Salford, UK

Sheba Pradeep, MSc, RN Adult, Lecturer in Adult Nursing, School of Health and Society, Mary Seacole Building, University of Salford, UK

Janine Bowshall, BSc, RN Adult, Lecturer in Adult Nursing, School of Health and Society, Mary Seacole Building, University of Salford, UK

Corresponding author: Melanie Stephens m.stephens@salford.ac.uk 0161 295 2877

Introduction:

Innovation in wound care has evolved over recent decades, which has resulted in a plethora of advanced therapies and wound care products available for use. Innovative technologies can improve both health and economic outcomes (Marjanovic et al, 2020), and the recent Covid-19 pandemic demonstrated an adaptable approach to wound care was achievable with the use of technologies such as telemedicine (Oropallo et al, 2021) and apps (Barakat-Johnson, 2022).

Innovation is often considered a complex process and not the straightforward invention, reinvention and introduction of wound care products and services (Madden & Stark, 2019). However innovative cost-effective practice is a necessity to manage the perceived future burden of wound care in financially challenged environments (Norman et al., 2016). Whilst technological advances are assisting to address this issue, another method is to demonstrate the utility and efficacy of cheaper existing technologies, products, and practices, which can offer alternative cost-effective solutions (Sarkar & Mateus, 2022).

In high income countries healthcare policy is driven by the delivery of improved wound management at lower costs through evidence-based practice (National Wound Care Strategy Programme 2022; Norman et al., 2016). Whereas in low to medium income countries wound care is motivated by affordability and accessibility (Gupta et al., 2021). Whilst opposing in approaches, the management of wounds is a global concern and it is widely acknowledged that wounds affect people of all ages, and the risk of developing a wound increases with age (Sen, 2021). The ageing population and associated risks of co-morbid illness (Šitum, 2014), wound development and the recognised adverse effects on healing impose significant burden on healthcare resources (Jarbrink et al., 2017). In the United Kingdom (UK) it was estimated the NHS managed 3.8million patients with a wound in 2017/18 costing £8.3billion. During this period however, 30% of all wounds remained unhealed at a cost of £5.6billion and 25% lacked a differential diagnosis (Guest et al., 2020).

It is clear from the literature that chronic wounds have a significant impact on patients', their significant others, healthcare systems, and society (Kapp & Santamaria, 2017; Phillips, Stanton,

Provan & Lew, 1994). Therefore, innovations that reduce the economic burden while lowering wound-related morbidity and mortality are needed more than ever (Gupta et al., 2021).

Frugal innovation

What is Frugal Innovation?

Since inception in The Economist in 2010, frugal innovation (FI) has gained popularity in healthcare and is considered *'a flexible approach to thinking about repurposing and sustainable resourcing'* (Bencsik, Machová, & Tóth, 2016). Although it is not a new concept, there are currently two schools of thought regarding the purpose of FI. On one hand FI provides innovative solutions using limited resources for populations in low-income to middle-income countries (LMICs), whilst on the other, FI is viewed as a cheaper and ineffective solution to a temporary problem (Tiwari, Fischer, & Kalogerakis, 2017). This difference of opinion on the purpose of FI and how it is used, for example to improve sustainability and adaptability whilst reducing costs, has impacted the definition. This means that FI continues to be considered as vague (Radjou, Prabhu, & Ahuja, 2012). The nebulous definition of FI is further compounded by the terminology used when referring to it such as Jugaad, Reverse Innovation, and Gandhian (See Table 1) (Hindocha et al., 2021) and the approach taken i.e '*doing more with less for more*' (Prabhu, 2017, p.1).

Table 1. FI definitions

Term	**Definition**
Jugaad	A flexible approach to problem-solving that uses limited resources in an innovative way
Reverse innovation	The process whereby goods are developed as inexpensive models to meet the needs of developing nations (e.g. The development of the World Alliance for Wound and Lymphoedema Care Wound Care Kit for less resourced countries, which contains sufficient material to produce up to 100 dressings (Vuagnat and Comte 2016); as an alternative to buying pre-made expensive dressing products typically available in UK health services.

Gandhian	This term is associated with two of Mahatma Ghandi's tenets: "*I would prize every invention of science made for the benefit of all*," and "*Earth provides enough to satisfy every man's need, but not every man's greed*." (Prahalad and Maskelkar, 2010) This philosophy places economic efficiency via innovation using existing resources accessible to the majority rather than the minority of health services capable of innovation involving the generation of entirely new technologies. Gandhian FI philosophy would arguably emphasise clinical outcomes as the key goal of innovation rather than economic productivity metrics as a priority.

Despite these complexities, for the purpose of this paper, FI is defined as "*low-cost and efficacious, new or adapted products (or services), mostly emerging from contexts of institutional voids and resource constraints, involving the creative use of existing resources*" (Sarkar, 2021, p.2). Whilst this definition omits the broad understanding of the original purpose of FI which was aimed at serving the needs of the underserved populations, it does address the need of finding relevance of FI in both LMIC's and high-income countries (HIC's) (Bhatti et al., 2017).

How it occurs in low-income settings

Since the industrial revolution healthcare systems and technologies have evolved and demonstrated improvements in the ability to prevent, diagnose, and treat diseases and illness (McClellan, 2008), impacting on global life expectancy and mortality. However, healthcare services are only available to half of the global population, with this figure expected to continue to rise (United Nations, 2020). Resource and financial constraints highlighted by the Covid 19 pandemic has led to urgent calls to find new and less expensive healthcare solutions (Sarkar, 2021).

Medical devices and products readily available in high resource countries are commonly unaffordable, inappropriate, and unusable to those who live and work in LMIC's. However, FI can contribute towards providing effective, affordable and inclusive solutions (Sarkar & Mateus,

2022) including a wide range of low-cost products, services, processes, or business models to underserved populations (Prabhu, 2017). FI in healthcare includes preventive tools, diagnostic and monitoring tools, surgical tools, and therapeutic or rehabilitative devices. Tran & Ravaud (2016) categorise FI into 4 types: lean tools and techniques, opportunistic solutions, contextualised adaptations, and bottom-up innovations. Table 2 provides some examples of the types of FI developed from LMIC's.

Table 2. Examples of FI in LMIC

Category of Frugal Innovation	**Description and example**
Lean tools and techniques	Simplification of existing technologies to reflect lower availability of resources such as free-range larvae therapy
Opportunistic solutions	Contemporary technologies are used to address 'old' clinical problems such as Video conferencing software to facilitate international consultation on clinical cases.
Contextualised adaptations	The diversion of existing tools for different purposes such as the use of papaya pulp for enzymatic debridement (Benskin, 2013).
Bottom-up innovations	The use of simple technologies to improve outcomes such as boiling or salination of water for use during wound cleansing or irrigation

Despite these innovations Sarkar & Mateus (2022) suggest three strategies are required when developing FI and this includes "*optimizing design function and performance according to the target market; optimizing the use of resources and cost minimization; and cooperation between entities*" (p.112). Clinicians and manufacturers providing low-cost solutions to a problem is not

effective FI, to be successful FI should adapt and tailor existing technology to the users' needs and circumstances.

Currently a lack of clinicians is the biggest resource challenge to health services and frugal innovation has been utilised to overcome this in LMICs. For example, the Basic Needs Program sought to train local health workers in Africa and Asia to identify and treat mental health problems whilst improving local access to medications and peer support services (Bhatti et al., 2017).

Within the field of tissue viability Ackers et al. (2020) found a lack of effective wound care was contributing to extended patient stays and inappropriate use of antibiotics for women post caesarean section in a Ugandan hospital. By engaging nurses and midwives to lead on improvements in wound cleansing and management practices, wound swabbing, laboratory testing and antimicrobial stewardship was transformed, and evidence based maternal sepsis became a multidisciplinary team approach.

Frugal innovation in the NHS

Frugal Innovation and the NHS

Whilst the NHS has a track record of creating and implementing innovations, it is less positive when adopting and diffusing them (ILC-UK,2017). Despite the introduction of the NHS Long term plan (DH, 2019) which states there is a need for the development of innovations in healthcare with plans to create simpler and clearer systems, FI's are often driven by cost savings when delivering evidence-based practice (Skopec, Issa & Harris,2019). Implementation is often due to lack of implementation research, clear guidance, and staff training (Stefani et al., 2022). Examples of FI in healthcare includes the adoption of Kangaroo Care in Midwifery and Community Health Worker (CHW) pilot in Westminster. Kangaroo care is a practice utilised by colleagues in Africa, Asia and South America, where a stable pre-term infant is placed skin-on-skin to the mother or father and is considered a safe, effective and low-cost alternative to incubators (Gregson & Blacker, 2011). Using a Brazilian Model of community health, CHW's in Churchill Gardens, London are assisting residents in managing their health, addressing

problems in health and well-being early on, reducing social isolation and improving uptake of screening and immunisation (NIHR Applied Research Collaboration Northwest London, 2022).

FI within the NHS have the potential to be multifaceted with beneficial outcomes including diagnostics of wound healing including wound photography and documentation, thereby improving the quality of care delivered (Wynn & Clark, 2022). Other FI such as the use of simpler and inexpensive mobile apps have helped clinicians access health data in real time (Dash et al,.2019). There are growing number of mobile applications intended for use by healthcare professionals or patients receiving care and recent survey data indicate that almost all (99.5%) clinicians caring for wounds in the UK already have access to smartphones with the majority having both a personal and work device (Wynn & Clark, 2022). These mobile applications may help with more accurate and faster assessment of wounds compared to traditional methods and represent a simple opportunistic solution to improving key wound care processes such as wound measurement and documentation (Wynn & Clark, 2022). However, it is necessary to consider that despite the ubiquity of the hardware for these apps the apps themselves come at a cost.

Role of Frugal Innovation in diagnostics and treatment within the NHS

FI have a potential for use in diagnostics and treatment within health care. A study conducted by Yang et al. (2011) concluded that there was no significant difference in outcomes between inguinal hernia repairs using low-cost and commercial mesh. Cost efficiency savings were noted in the successful use of mosquito nets used in low-income countries for hernia repair. The use of the mosquito net mesh for hernia repair within the NHS would present a major cost savings (Skopec, Issa & Harris, 2019). Similarly, the use of Ankle Brachial Pressure Index (ABPI) is considered the gold standard in the diagnosis of Peripheral Arterial Disease (PAD) (Papanas et al., 2010). Diagnosis of PAD is crucial to prevent limb ischemia and disease progression (Papanas et al., 2010). ABPI is measured using a portable doppler ultrasound; its use requires skill and competence. However, the use of pulse oximetry requiring less skills and training has been shown to be useful in monitoring adequacy of arterial blood supply (Bianchi et al., 2000). An early study by Bianchi et al. (2000) found that using pulse oximetry (the Lanarkshire

Oximetry Index -LOI) enables measurement of small vessel perfusion which was difficult to measure using a doppler assessment. It could therefore improve early detection of venous ulcer patients who are suitable for compression therapy. The use of relatively cheap pulse oximetry devices as part of an LOI procedure, for screening PAD may therefore potentiate cost efficiency savings if used within the NHS. The use of cheaper and more accessible assessment processes for screening leg ulcer patients for arterial disease has the potential to be impactful given recent data indicating that around 70% of leg ulcers are venous in aetiology and only 15% of patients with ulcers receive an ABPI assessment (Guest et al., 2020). As the efficacy of early compression is well established (Shi et al., 2021), improved access to timely compression may have a clinically significant impact on healing outcomes. However, further investigation of the LOI is required to ensure it is clinimetrically suitable for routine screening of patients for PAD.

Frugal innovation using self-care models

During Covid 19, national lockdowns led to the introduction of self-care guidelines and videos for patients with chronic wounds. The purpose of such initiatives was not to replace treatment needs but minimise the risk to patients and staff. From the literature self-care initiatives for patients with long term conditions is not a new phenomenon as examples such as the Lyndsey Leg Club (based upon the social care model) has demonstrated that patient empowerment and self-care improve concordance with wound management (Bailey & Wright, 2016).

Lack of clinicians in the NHS remains a challenge. However, FI methods such as digital tools such as video conferencing which were used during the pandemic by Community Health workers, who previously lacked digital capabilities. This helped to provide essential health care services and played a vital role in care delivery whilst trying to limit the spread of the coronavirus during thepandemic.(Feroz,Khoja and Saleem, 2021).

Implementing Frugal Innovation into clinical guidelines

According to Sharma, Harris, Agrawal, & Agarwal (2021) the implementation of FI into HIC's clinical guidelines is complex due to two reasons. The first is that FI is often an unconventional method which has been introduced to decrease costs or complexities in LMIC's healthcare delivery. The ideas are usually unpatented, not financed or commercialised, and include simple

changes to practice. The second is that FI often stem from LMIC's where it is challenging to conduct and report on research findings. Therefore, FI remains invisible and less likely to be disseminated in peer review journals and conferences or be incorporated into clinical guidelines and practice. Sharma et al. (2021) call for guidelines that assist in the standardised reporting of FIs as the authors feel *'reporting of an innovation differs materially to the reporting of research'* (p. 2). They suggest the STandardised Reporting Of Novel Grassroots Frugal Innovation (STRONG-FI) template which allows detailing of the FI from *'ideation to development, usage and diffusion'* (p.3). The STRONG-FI provides clinicians with prompts so they can examine the motivation for FI development and discussion of the barriers during implementation. The template also allows internal and external validation, with the development of standards for sustainability and safety. Finally, Sharma et al. (2021) suggest that the STRONG-FI framework will signal rigour and objectivity in the communication of knowledge and expertise from LMIC authors to communities less receptive to FI, as it provides the necessary structures to meet the Introduction, Methods, Results and Discussion (IMRAD) structure (traditionally used to report scientific papers) a prerequisite for peer review and subsequent peer acceptance.

Conclusion

With both the increasing prevalence and clinical acuity of patients with wounds in the UK it is essential that alongside harnessing cutting-edge new technologies, frugal innovation is also pursued. This may improve both economic efficiency and patient outcomes. Many frugal innovations were adopted throughout the COVID-19 pandemic in order to ensure clinical services remained accessible, often utilising opportunistic solutions such as video conferencing services to run clinics. However, there are many more opportunities for frugal innovation in wound care, including the use of smartphone technology which is already accessible to 99.5% of clinicians caring for wounds, or the simplification of basic screening for arterial disease to increase accessibility to timely compression therapy. Clinicians working in wound care should consider their access to existing resources which may not currently be considered useful for wound care processes and explore how these could be used to improve wound care outcomes. Frugal innovation philosophies pioneered in low-income settings should be adopted by UK

clinicians to harness the potential benefits to patients such outlooks may yield to clinical outcomes.

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