Opinion

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Toward Sustainable Wound Bed Preparation: Rethinking Medical-Grade Honey in Pediatric Burn Care

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Introduction

Burn injuries remain an important cause of preventable death and disability in children (World Health Organization, 2023). Their consequences extend well beyond the initial wound: prolonged treatment, repeated painful procedures, contracture and functional loss, psychological distress, and impaired quality of life may continue long after the acute episode (Meng et al., 2020; Spronk et al., 2018; Woolard et al., 2021). These harms are not evenly distributed. Children in low- and middle-income countries bear a disproportionate share of burn morbidity while often receiving care in settings with limited access to specialist teams, surgery, rehabilitation, and reliable wound-care supplies (Bresler et al., 2022; Meng et al., 2020; World Health Organization, 2023).

Advances in burn care have improved outcomes in well-resourced centers, but access to specialist services remains markedly unequal (Bresler et al., 2022; World Health Organization, 2023). A dressing may perform well under controlled conditions and still have little practical value where its price is prohibitive, procurement is intermittent, storage is difficult, or trained staff are unavailable. In such settings, the success of treatment depends not only on biological efficacy but also on whether care can be initiated promptly, repeated safely, and maintained until healing is complete.

Medical-grade honey offers a useful lens through which to examine this gap. Honey's biological activity and potential for local sourcing make it relevant to research at the intersection of wound biology, antimicrobial stewardship, sustainability, and health equity (Mandal & Mandal, 2011; Tran & Ravaud, 2016). Any clinical or economic advantage, however, depends on the feasibility of producing and supplying sterile, standardized, quality-assured preparations.

This Opinion does not argue that honey should replace advanced dressings or that unprocessed household honey should be applied to burns. Rather, it asks a broader question: how should a dressing be valued when most children with burns live in health systems where the most technologically sophisticated option may not be consistently available? We propose that medical-grade honey should be reconsidered as an evidence-informed example

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of context-appropriate wound care and use it to introduce Sustainable Wound Bed Preparation, a conceptual framework that links optimization of the wound microenvironment to the capacity of the healthcare environment to deliver treatment reliably.

Why Pediatric Burn Care Needs Sustainable Solutions

Pediatric burn care is resource-intensive and may require sustained multidisciplinary input (Bresler et al., 2022; Meng et al., 2020). Even relatively small injuries may require repeated assessment, cleansing, analgesia, dressing changes, infection surveillance, rehabilitation, and caregiver education. Delayed access to appropriate burn care is associated with preventable late complications, including hypertrophic scarring and contracture (Meng et al., 2020). These demands are especially difficult to meet in rural hospitals, humanitarian settings, and health systems affected by workforce shortages, political instability, climate-related disruption, or fragile procurement networks.

Cost is only one part of the problem. Many advanced products depend on continuous importation, predictable cold or dry storage, specialized equipment, or staff familiar with a narrow application protocol. A temporary stock-out can interrupt an otherwise effective treatment plan. Families may also face repeated travel, lost income, and out-of-pocket expenditure. A dressing that reduces bedside complexity or dependence on unstable supply chains may therefore create value that is invisible in conventional product comparisons.

Sustainability in wound care should consequently be understood in three connected senses. First, treatment must be clinically sustainable: it should support healing without imposing avoidable pain, toxicity, or procedural burden. Second, it must be operationally and economically sustainable: the necessary material, skills, and follow-up must remain available throughout the episode of care. Third, it should be environmentally responsible, with attention to manufacturing, transport, packaging, waste, and the frequency of dressing changes (World Health Organization, 2020, 2024). These dimensions do not weaken standards of care; they clarify what effective care requires in the real world.

This perspective changes the clinical question. Instead of asking only which dressing performs best under ideal conditions, clinicians and policy makers must also ask which safe and effective option can be implemented at the required scale and maintained over time. Naturally derived products merit scientific attention within this discussion, not because scarcity should justify lower standards, but because locally adaptable interventions may sometimes combine acceptable clinical performance with greater resilience and reach.

Why Medical-Grade Honey Deserves Renewed Attention

Honey has often been discussed as a collection of discrete antibacterial, anti-inflammatory, antioxidant, debriding, and pro-healing properties (Oryan et al., 2016). That list is accurate in outline but conceptually incomplete. Modern wound care is increasingly concerned with the dynamic microenvironment in which repair occurs. From this standpoint, the relevant question is not whether a dressing possesses one desirable feature, but whether its combined effects help restore the conditions required for orderly healing.

Honey's physicochemical and biological characteristics may act in concert (Mandal & Mandal, 2011; Oryan et al., 2016). High osmolarity and an acidic pH can create conditions unfavorable to microbial proliferation; enzymatic generation of hydrogen peroxide and other bioactive constituents may contribute additional antimicrobial activity; and polyphenols and flavonoids may influence oxidative stress and inflammation (Mandal & Mandal, 2011; Oryan et al., 2016). Its viscous, moist interface may protect exposed tissue, support autolytic debridement, and reduce adherence to the wound surface (Mandal & Mandal, 2011; Oryan et al., 2016). These mechanisms and their potency vary among honey types and preparations, which is clinically important, but together they provide a plausible basis for considering honey a modulator of the wound microenvironment rather than a single-purpose topical agent (Irish et al., 2011; Mandal & Mandal, 2011).

The distinction matters in pediatric burns. Burn treatment and dressing-related procedures can produce substantial pain, fear, and anticipatory anxiety, with consequences for children and

caregivers (Woolard et al., 2021). In pediatric deep partial-thickness burns, the principles of nonsurgical treatment focus on preventing infection, protecting the remaining epithelial tissue, and creating an optimal environment for wound re-epithelialization (Gee Kee et al., 2013). A treatment that maintains a moist environment and limits adherence could reduce adherence-related trauma during dressing changes, but this potential benefit has not been established specifically in pediatric burns (Mandal & Mandal, 2011; Weissenstein et al., 2014). These potential advantages must be tested rather than assumed, but they align with a patient-centred view in which comfort, continuity, and caregiver feasibility are part of therapeutic effectiveness.

Renewed attention must also be accompanied by safeguards. The composition and antimicrobial activity of natural honey are not uniform (Irish et al., 2011; Mandal & Mandal, 2011). Microbial contamination, including bacterial spores, and inconsistent sourcing or processing can compromise safety and reproducibility (Molan & Allen, 1996; Simon et al., 2009). The case for honey in modern practice is therefore a case for sterile, standardized, quality-assured medical-grade preparations and clear protocols—not for the unsupervised application of food-grade honey to open wounds (Molan & Allen, 1996; Simon et al., 2009).

Medical-grade honey (MGH) must undergo sterilization to ensure safety and minimize microbial contamination, including bacterial endospores such as Clostridium botulinum and C. tetani (Scepankova et al., 2022).

However, sterilization alone cannot remove contaminants such as pesticides and heavy metals, while thermal sterilization may degrade enzymes, vitamins, and phenolic compounds and increase the formation of 5-hydroxymethylfurfural (HMF), a marker of honey deterioration [Enrique & Tatiana, 2017,Irungu et al., 2016,Scepankova et al., 2022,Shapla et al., 2018]. Gamma irradiation is considered a standard method for sterilizing MGH, and evidence suggests that even relatively high doses, despite causing some physicochemical changes, do not necessarily result in a significant reduction in honey's antibacterial activity [Horniackova et al., 2017,Molan & Allen, 1996,Kapoor & Yadav, 2021]. Among different types of MGH, Manuka honey exhibits substantial antibacterial activity due to its methylglyoxal (MGO) content, low pH, and high osmolarity, including activity against antibiotic-resistant bacteria such as MRSA. Other MGH products, including Revamil and Gelam honey, also demonstrate antibacterial activity through peroxide-dependent and peroxide-independent mechanisms involving components such as bee defensin-1 and H_2O_2 [Kapoor & Yadav, 2021,Ahmed et al., 2022,Kwakman et al., 2011,Zainol et al., 2013,Nolan et al., 2020].

What Current Clinical Evidence Suggests

The clinical evidence suggests a potential role for honey in wound management, but its strength varies by wound type and comparator, and evidence in children remains particularly limited (Jull et al., 2015). Biological plausibility alone cannot establish clinical benefit.

Clinical studies, case series, and pediatric observations have described reductions in microbial burden, progression of granulation tissue, autolytic debridement, and advancement toward wound closure. These findings should nevertheless be interpreted cautiously. Sample sizes are often small, wound etiologies and severities are heterogeneous, and the literature includes a substantial proportion of observational reports and case series. Differences in honey source, processing, sterilization, formulation, comparator treatment, and outcome definition further limit direct comparison between studies (Jull et al., 2015; Weissenstein et al., 2014).

Laboratory findings should be distinguished from clinical outcomes. In vitro activity against organisms implicated in wound infection, including Staphylococcus aureus, Pseudomonas aeruginosa, and antibiotic-resistant strains, does not establish a reduction in infection rates in pediatric burns (Irish et al., 2011; Mandal & Mandal, 2011; Nolan et al., 2020).

The pediatric literature, although limited, provides clinically relevant observations. Vardi et al. (1998) described nine neonates and infants with large postoperative infected wounds that had not improved after at least 14 days of conventional systemic and local antimicrobial treatment. Marked clinical improvement was observed within five days of topical honey application, and after 21 days all wounds were reported as closed, clean, and sterile, with no treatment-related adverse reactions. Later pediatric reports and case series have similarly described granulation, autolytic debridement,

epithelial progression, and healing in complex wounds, including pressure injuries, traumatic wounds, surgical wounds, and thermal burns (Simon et al., 2009; Smaropoulos & Cremers, 2020; Weissenstein et al., 2014).

A small pediatric comparison of honey-based treatment with a conventional hospital protocol reported shorter healing times, approximately 19 days compared with 25-31 days, without infections or adverse effects in the honey-treated group (Smaropoulos et al., 2011). These findings are encouraging but should be interpreted as hypothesis-generating because of the small sample, retrospective comparator, and mixed wound population. Likewise, the Cochrane review found that honey dressings may accelerate healing in some partial-thickness burns compared with selected conventional dressings, but substantial heterogeneity and low or very low certainty for several comparisons prevent broad conclusions about superiority (Jull et al., 2015).

Available reports suggest acceptable tolerability, although local discomfort or hypersensitivity may occur. Current pediatric evidence is insufficient to define a precise place for medical-grade honey within standardized burn pathways. Its clinical role requires prospective comparison using well-characterized preparations and clearly defined pediatric burn populations.

Honey as a Model for Sustainable and Equitable Wound Care

The broader significance of honey is not that it is ancient or natural. It is that it illustrates how a wound-care intervention can be judged simultaneously at biological and system levels. If produced, processed, sterilized, tested, and distributed to an appropriate clinical standard, honey-based dressings may offer a route to reducing dependence on imported materials while retaining a biologically credible therapeutic function. This possibility makes honey a useful case through which to examine frugal innovation: not a cheaper imitation of high-technology care, but a context-responsive solution designed around local constraints and needs (Tran & Ravaud, 2016).

Local production is not automatically equitable or sustainable. Benefits depend on governance, quality assurance, traceability, fair procurement, environmental stewardship, and protection against market exploitation. Regions with local apiculture may have an opportunity to investigate shorter supply chains and local technical capacity, but whether this produces clinical, economic, or environmental benefit requires direct evaluation; clinical-grade preparation also requires investment and regulation. Without these safeguards, variability and contamination could shift risk onto the very populations the intervention is intended to serve.

Environmental claims likewise require evidence. A product may be locally sourced yet carry substantial processing, packaging, sterilization, or transport impacts. Conversely, a dressing that decreases material use or the number of changes could reduce waste and staff time, but this has not been demonstrated specifically for honey dressings (World Health Organization, 2024). Life-cycle assessment, waste audits, and context-specific economic evaluation should therefore accompany clinical trials. Sustainability should be measured, not treated as an intrinsic property of anything labelled natural.

Health equity is the central test. Context-appropriate care should expand access to safe, effective treatment without creating a two-tier standard in which children in poorer settings are offered interventions that would not withstand scientific scrutiny elsewhere. The appropriate principle is parity of therapeutic intent with flexibility in delivery: the same commitment to healing, pain control, infection prevention, function, and dignity, achieved through interventions that the local system can reliably support.

Toward a Sustainable Wound Bed Preparation

Wound bed preparation shifted clinical attention from isolated products to the coordinated management of tissue viability, inflammation and infection, moisture, and progression at the wound edge (Schultz et al., 2003, 2004; Sibbald et al., 2021). That change was important because healing depends on interactions within a dynamic biological environment. Yet in resource-constrained pediatric burn care, optimization of the wound itself is only part of the task. The selected intervention must also survive the economic, logistical, organizational, and social conditions through which care is delivered.

We therefore propose Sustainable Wound Bed Preparation (SWBP) as a conceptual extension of existing wound-bed approaches (Figure 1).

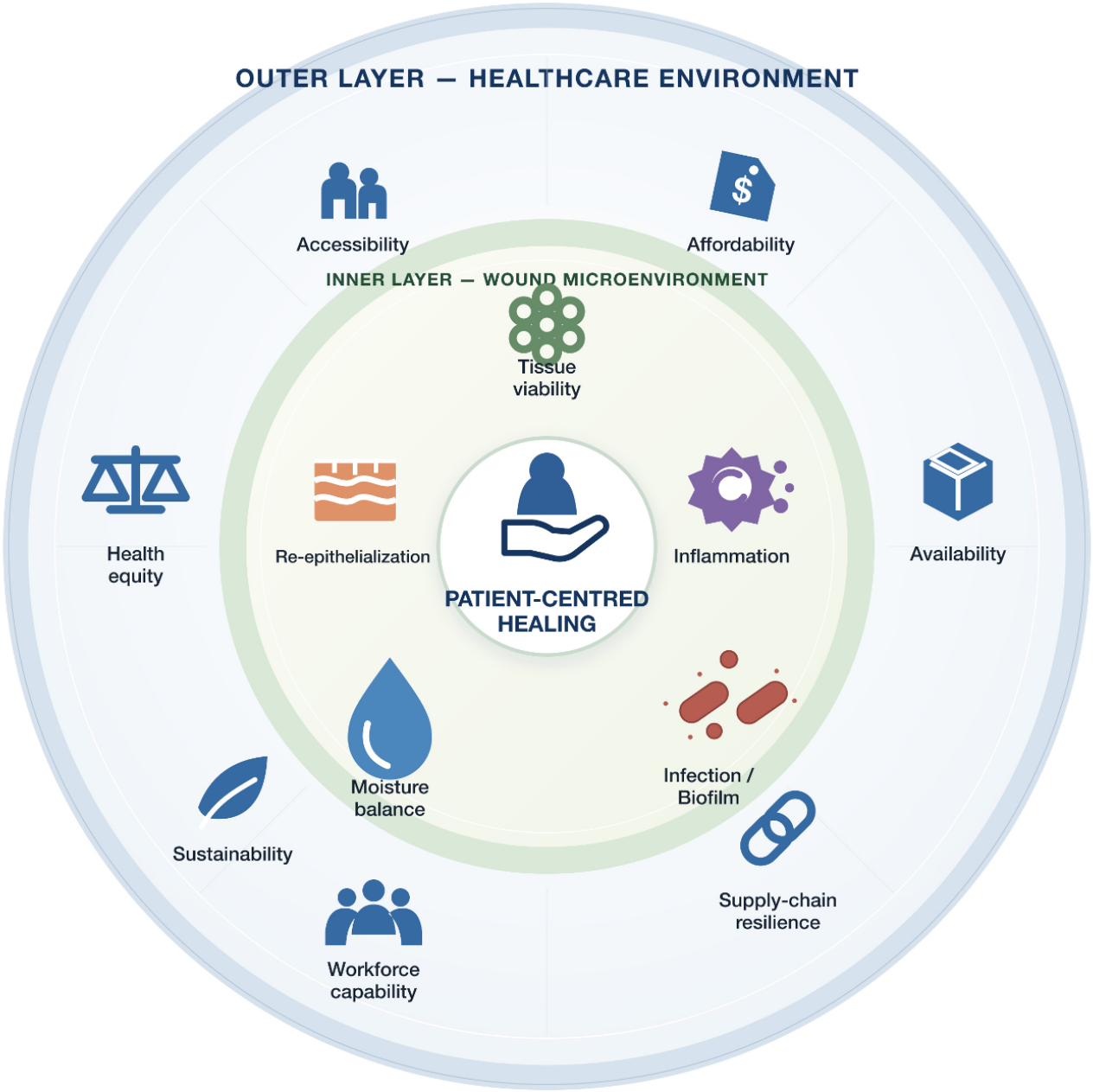

Figure 1. Sustainable Wound Bed Preparation framework.

SWBP does not alter the biology of healing and is not presented as a validated tool, checklist, or scoring system. It broadens the field of view. Patient-centred healing sits at the center of two interdependent layers: an inner wound microenvironment and an outer healthcare environment. The inner layer includes tissue viability, inflammation, infection and biofilm, moisture balance, and re-epithelialization. The outer layer includes accessibility, affordability, availability, supply-chain resilience, workforce capability, sustainability, and health equity.

The concentric arrangement is deliberate. The healthcare environment surrounds every biological decision. A theoretically ideal dressing cannot optimize the wound microenvironment if it is unavailable, unaffordable, repeatedly out of stock, too complex for the available workforce, or unacceptable to children and caregivers. Conversely, low cost and local availability cannot compensate for inadequate safety or biological performance. Clinical value emerges from the

fit between both layers, with the child's healing, comfort, function, and dignity as the organizing purpose.

Medical-grade honey offers a test case for examining the relationship between these layers. Its effects on the wound microenvironment, including antibiofilm activity demonstrated in vitro, provide a biological rationale for investigation (Lu et al., 2014; Oryan et al., 2016; Sojka et al., 2016). Whether a quality-assured preparation can also meet local service requirements must be evaluated in the setting where it would be used.

SWBP could guide research and service design by expanding the outcomes considered in dressing studies. Alongside healing and infection, investigators could measure stock continuity, staff training needs, application time, caregiver acceptability, total treatment cost, waste generation, environmental burden, and distribution of benefit across geographic and socioeconomic groups. Comparative effectiveness research could then identify not merely which product performs best, but which care strategy delivers the most reliable patient-centred outcome within a defined context.

Clinical Implications

Honey should be considered only as a quality-assured, standardized wound-care intervention and not as unprocessed household honey applied to open wounds.

In pediatric burns, any honey-based dressing should be integrated within comprehensive burn assessment and treatment; it does not replace analgesia, infection management, rehabilitation, or surgery when these are indicated.

Treatment selection should consider both biological performance and the ability of the healthcare system to provide the intervention safely and consistently, particularly where access, cost, workforce, and supply continuity constrain care.

Conclusion and Call to Action

Medical-grade honey provides a useful case for examining Sustainable Wound Bed Preparation, but neither its biological rationale nor its potential for local production establishes clinical superiority or affordability (Oryan et al., 2016; Tran & Ravaud, 2016). The next step is a staged research agenda.

First, establish product quality and feasibility through standardized characterization, validated sterilization, contaminant testing, traceability, and assessment of whether the preparation can be supplied and applied reliably. Second, undertake adequately powered comparative pediatric studies that specify burn depth and extent, age group, honey formulation, and comparator. Distinguish time to wound closure or re-epithelialization from longer-term scar and functional outcomes, and include pain, infection, adverse events, and caregiver burden. Third, assess implementation, total treatment costs, equity, and environmental performance, using life-cycle assessment where appropriate. Planning should involve clinicians, children and caregivers, producers, regulators, and relevant research specialists from the outset; broader implementation should depend on the preceding quality, feasibility, and clinical findings.

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