A Review of the Literature Informing Affordable, Available Wound Management Choices for Rural Areas of Tropical Developing Countries

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Abstract
Health professionals are often absent in rural areas of tropical developing countries. Current wound management in this environment is costly and largely ineffective. Achieving effective wound management in this setting will require educating the lay health providers who manage wounds in villages. Two extensive literature searches were conducted using CINAHL and Medline with no date, geographic, or language restrictions. The question, “What is the evidence base for topical wound treatments and dressings that are affordable and available in developing countries?” was addressed by critically evaluating all 18 identified clinical studies and reviews. The results suggest that a moist wound environment can be maintained using improvised dressings such as banana leaves, saline-soaked furniture foam, and food wrap, and that these choices are superior to many commercial dressings. Some varieties of honey, papaya pulp, EUSOL, and lubricating jelly are effective, affordable substances for treating and debriding wounds. Papaya pulp can be unsafe if not very closely monitored. No studies addressing the second question, “What are the topical wound management interventions currently being used in rural areas of tropical developing countries?” were found. However, 13 articles that could guide the design of research studies in this field were identified and are reviewed here. This literature describes a wide variety of wound prevention and management methods, some known to be deleterious for healing. These two literature reviews reveal the large gaps in the evidence base on available and affordable wound treatment options for rural patients in developing countries. Future research should address these gaps.

Keywords: wounds, developing countries, rural, village health workers, affordable

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The World Alliance for Wound and Lymphedema Care (WAWLC) was formed by the World Health Organization (WHO) in 2009 based upon strategies recommended by the Association for the Advancement of Wound Care (AAWC) Global Alliance, Handicap International, and other interested nonprofit organizations.1 The formation of this alliance demonstrates a new interest in wound care in resource-limited environments.1 These efforts to improve wound management in developing countries should be guided by well-designed clinical research studies evaluating economical wound management choices.

Current wound management in these rural areas is costly and largely ineffective.2 When villager self-care (VSC) with traditional medicine or drugs purchased from roadside drug peddlers fails, wound management is usually performed by traditional health practitioners (THPs).3,4 In some rural areas where health professionals are not readily available, minimally trained village health workers (VHWs) provide basic scientifically verified curative care and promote health.5,6 Experts agree that achieving effective wound management in rural areas of tropical developing countries will require educating the VSCs, THPs, and VHWs in these areas.3,7-9

A Certified Wound Care Nurse, Certified Wound Specialist, PhD-prepared nurse educator, this author has experience providing healthcare and teaching VHWs and VSCs while living for 5 years in a remote area of Ghana, West Africa, and on multiple short-term medical trips worldwide over a span of two decades. Her long-term research and educational goals...
are to improve the health of villagers in tropical developing countries by validating safe, effective, sustainable health promotion, illness prevention, and treatment protocols, including wound management protocols, and then teaching this information to indigenous nonprofessional health providers.

The 2010 Joint Conference of the Wound, Ostomy and Continence Nurses Society (WOCN) and the World Council of Enterostomal Therapists (WCET) brought together 4,600 nurse professionals from all over the globe, most of whom spend the majority of their time providing wound care in an acute care setting. The nurses working in the United States, Canada, Europe, and Australia choose dressings and treatments for their wound patients from the impressive array of thousands of products from nearly 100 manufacturers vying for their attention in the WOCN/WCET conference exhibit hall. Such wound care products account for $15.3 billion of healthcare outlays in the United States alone.

Away from the attractive displays of the exhibit hall, a nurse from Indonesia presented excellent outcomes obtained in diabetic foot ulcer patients using a homemade concoction of metronidazole, petroleum jelly, zinc, and nystatin. The lack of availability of commercial wound dressings to promote moist wound healing for patients in resource-limited environments has spawned such innovation. Following this presentation, wound nurses who work in India and Africa crowded the podium, seeking the recipe and exchanging ideas with one another. Of the 193 independent states in the world, the 104 listed in the Multidimensional Poverty Index as developing countries are home to 78% of the world’s population. The 1.4 billion people who live on less than $1.25/day cannot afford modern wound care products such as those presented in the WOCN/WCET exhibit hall.

The purpose of this article is to critically review the available evidence for wound management methods that can realistically be implemented in this challenging setting.

Background: Modern Moist Wound Management

Microbes thrive in warm, moist environments, leading to the common belief that wounds must be dressed in a way that allows them to “breathe” to avoid infection, a practice that persists to this day. During World War II, Captain Bloom, a British medical officer in a prisoner-of-war camp, determined that cellophane, a semipermeable membrane, was far superior to porous petrolatum gauze in supporting the healing of burn wounds among his fellow prisoners. Captain Bloom found moisture-retentive cellophane kept infectious organisms out of the wound bed, kept the body’s healing nutrients in the wound bed, permitted excess moisture to escape, and dramatically decreased pain. In 1948, Gilje, a Swedish doctoral student, found that occluding wounds with adhesive tape dramatically sped healing. However, these discoveries did not result in clinical practice changes.

Two decades later, Winter proved experimentally that when wounds are covered with moisture-retentive dressings, they heal much faster than wounds open to air. Moisture allows the healing cells of the body to migrate more freely and gives them access to nutrients. Winter’s research was timely, helping give birth to the new health specialty of wound care predicated on the revolutionary idea that moist wound healing is the ideal. Manufacturers have capitalized on the growing demand for products that support moist wound healing, leading to an exponential growth in commercial wound dressing choices.

I. Improvised Dressings and Treatments

Most of the wound management products tested by researchers are cost-prohibitive in resource-limited environments. Therefore, the question, “What is the evidence base for topical wound treatments and dressings that are affordable and available in developing countries?” is a challenging one to research. The author has conducted comprehensive searches of the literature on this topic since 2011 to discover sustainable wound management solutions to teach villagers. In May 2013, an information science expert with experience searching the complementary/alternative medicine literature provided assistance. This helped ensure that all pertinent articles were found. Inclusion criteria were: a report of a clinical trial on wounds that extend beyond the dermal layer of the skin in humans or a review of such clinical trials, and the intervention product could be either purchased affordably or improvised without special equipment by health practitioners in developing countries.

CINAHL and Medline (using both PubMed and Ovid) were searched using several combinations of search terms. For example, one Medline search was: (wound healing [MeSH Terms] OR wound OR wounds OR ulcer OR ulcers OR ulceration OR ulcerations OR lesion OR lesions OR sore OR sores OR burn OR burns) AND (village OR developing OR Africa OR India OR Asia OR tropical or tropics) AND (sustainable

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OR alternative OR affordable OR cost OR inexpensive OR economical) NOT spinal NOT eye NOT ocular NOT cervical NOT pylori. Filters were human and clinical trials or reviews of clinical trials. Because the literature on this topic is sparse, no date, geographic, or language limits were placed on the searches. Virtually all of the articles were written in English or had English abstracts. Those that did not were in German, a language in which the author is conversant.

All articles that might possibly pertain to the research question were retrieved, and an ancestry search was done on the relevant articles. Publications with the word tropical in the title were searched independently for any reference to wounds. Articles also were solicited from other experts in the field. All 18 articles that met the inclusion criteria were written in English and are reviewed here. Because the most efficacious, affordable interventions may be very basic, decades-old citations are included in this review.

**Improvised Dressings to Maintain Wound Moisture**

**Boiled potato peel (BPP).** Burn wounds must be protected from dehydration and contamination to prevent necrosis. In the Netherlands, grandmothers advocate covering burns with the thin outer peel of boiled potatoes, a widely available and inexpensive semipermeable membrane. Since 1962, when Winter established the benefits of moist wound healing, potato peel dressings have been the object of several research studies. Keswani and Patil pioneered these efforts in Mumbai (Bombay), India, in the 1980s.

Keswani and Patil added Vartak and Davies to their team for their 1990 study, which examined histology, bacteriology, and clinical outcomes in burns covered with a secondary dressing of either BPP or gauze. This study included 17 patients with burns or scalds distributed over their bodies evenly enough for them to serve as their own controls. Because wound infections were ubiquitous in this burn unit, silver sulphadiazine cream (SSD) was applied to all burned areas on all patients. Half of the burned area on each study patient then was covered with potato peel dressings; a clinically equivalent other half was covered with gauze dressings. Photos, swabs, and punch biopsies were taken of wound tissue from beneath each dressing type on each patient on days 0, 4, 8, 15, and 21. Aerobic cultures were not consistently different between groups. The BPP dressings led to faster healing, with histology showing orderly stratification of cells, indicating a strong scar. The wound areas dressed with BPP did not become macerated or dehydrated, and none of these wounds required grafting. Patients were more comfortable with the BPP dressings than with gauze dressings. Using patients as their own controls effectively eliminated many of the confounding variables inherent in wound research. Limitations of this study were the small sample size, lack of binding or randomization, that anaerobes were not cultured, and that the method of preparing the dressings (the peels are removed from the potatoes and then glued, edge-to-edge, to a single layer of gauze, which becomes the outer bandage) is complex and time-consuming. Also, SSD is not available in many resource-limited environments.

Patange et al, also in Mumbai (Bombay), India, chose a mixed methods format to compare BPP dressings to gauze in erosive wounds (pemphigus, bullous pemphigoid, and leg ulcers) in 11 patients with a total of 25 wounds, publishing their results in 1996. Wounds were cleaned, and then a BPP dressing with a thin layer of antiseptic cream, and in the cases of pemphigus, steroid cream, was applied. In two patients with pemphigus wounds on symmetrical sites, conventional gauze dressings were compared with BPP dressings. In these two patients, wounds covered with BPP dressings healed in 7 days, while the lesions covered with gauze remained open after 2 weeks. The conventional dressing was changed to a BPP dressing at 2 weeks, and the wounds closed 1 week later. None of the patients developed secondary wound infections, and none of the wounds deteriorated. With the exception of a patient with toxic epidermal necrolysis who died, all of the wounds closed in 28 days, including difficult-to-heal wound types. Patients found the BPP dressings to be comfortable and cooling, presumably because they allow the exchange of moisture vapor and gases. These dressings also protected the wounds from friction or trauma, and were cost effective, easy to prepare, and nonadherent, an important attribute of an ideal wound dressing. This study showed BPP dressings can be efficacious in a clinical setting in patients of diverse ages with a variety of wound types. However, aside from the two patients with symmetrical wound sites, there were no controls, and the use of antibiotic cream on every wound avoids questions of a possible increase in infection risk with BPP dressings.

**Banana leaf** (see Figure 1). Prasannababy, a nursing instructor, published a five-paragraph summary of a prospective randomized, controlled trial (RCT) conducted in Chennai (Madras), India in 2000, comparing banana leaf dressings to paraffin gauze on burn patient donor sites. Thirty patients were randomly assigned to the two treatment groups. The researchers evaluated cost, efficacy, and pain. Banana
leaves were found to be as effective as paraffin gauze with significantly less pain overall (P <0.05), no pain at dressing changes, and dramatically lower costs. Unlike potato products, banana leaves are widely available in the tropics. The banana leaves were autoclaved (ie, sterilized using high-pressure steam), which would not be possible in the village setting. No further details were provided.

Gore and Akolekar26 reported on a study in Mumbai (Bombay), India, in 2003 comparing banana leaf dressings with BPP bandages on 30 patients who had sustained partial-thickness burn wounds of up to 50% body surface area that could be divided into two equal parts (usually contralateral limbs) so patients could serve as their own controls. Petroleum gauze had led to traumatic dressing changes because it is not completely nonadherent. BPP dressings were nonadherent, leading the facility to adopt them as standard treatment for burns. However, as was the experience of Keswani et al (and in contrast to Patel et al), Gore and Akolekar observed that preparation of BPP dressings was time-consuming and difficult to teach, leading them to search for another affordable, nonadherent dressing material.

Gore and Akolekar26 discovered that banana leaf dressings are far less expensive and easier to handle than BPP dressings. Pain, comfort, date of epithelialization or eschar formation, the need for grafts, and microbiological studies also were assessed for both dressing types. Although they are not semipermeable, banana leaf dressings were equal or superior to BPP dressings in every parameter tested and cost one tenth as much to prepare. The study was well designed: patients served as their own control and outcome measures were practical. Limitations included no blinding of clinicians or patients, the side on which the banana leaf dressing was used was not randomized, and all wounds were treated with povidone iodine ointment, obscuring any differences in the dressings' ability to ward off infection. The facility adopted banana leaf dressings as their standard for burns, using them to successfully treat more than 2,000 burn patients.

In 2010, De Buck and Van de Velde27 of the Belgian Red Cross examined the evidence for using BPP dressings rather than gauze alone for the acute management of burns. The authors found no studies of BPP being used as a first aid dressing. Three studies from India, all of which are reviewed here, met their criteria for relevance and quality. From these studies, the researchers concluded BPP serves to decrease wound desiccation, which can speed healing, but BPP dressings did not appear to have any antimicrobial properties. The authors also found that banana leaves were as effective as BPP dressings; they concluded more well-designed studies are needed.

Polyurethane foam. Polyurethane foam dressings are relatively inexpensive compared to many other modern moist wound dressings.28 Sopata et al28 compared plain polyurethane foam dressings to hydrogel dressings in a RCT of 34 advanced cancer patients with 38 Stage II and Stage III pressure ulcers in Poland in 2002. The focus of the study was on how bacteria affect occlusive wound healing. Results of qualitative and quantitative bacterial studies, as well as efficacy (wound closure or cm² reduction in wound size), were reported at three intervals over a period of 8 weeks. Efficacy was not statistically different between the two dressings. The less expensive polyurethane foam dressing promoted faster healing, but the rate did not reach statistical significance. Bacteria under the dressings varied over the course of the first 3 weeks for both dressings, but even when counts were >10⁶, bacteria did not significantly affect healing rates or result in signs of infection. The researchers concluded occlusive dressings are safe and effective for the treatment of pressure ulcers, even in cancer patients. A strength of this study is that anaerobic bacteria, as well as aerobic bacteria, were cultured. Limitations of the study are the small sample size, lack of blinding, and the lack of a description of how bacteriological samples were taken.

Medical-grade foam dressings are relatively inexpensive modern wound dressings, but even these dressings are cost-prohibitive for many patients in resource-limited environments.29 In 2006, Varma et al29 reported on a study in which industrial-grade polyurethane foam (upholstery foam) was sterilized and cut it into dressings, testing the foam in a RCT of 48 patients with diabetes with debrided lower limb wounds in Kochi (Cochin), India. The foam was soaked in saline, wrung out, then placed directly on the wounds of 24 patients without any topical treatments. The foam dressings were covered with gauze pads and wrapped with an elastocrepe bandage. The remaining patients received standard modern wound care, which consisted of applying topical antibiotics or enzymatic debriders or hydrogel or hydrocolloid dressings as deemed necessary. The affected limb for both groups was strictly offloaded. Family or neighbors were taught to perform outpatient dressing changes. All patients were followed-up for at least 3 months. The foam was found to be relatively nonadherent and very absorbent. Wound healing occurred in significantly fewer days in the foam dressing group. All of
the foam dressing group patients’ wounds closed, while seven of the 24 patients in the standard care group had incomplete wound healing. Some patients from both groups underwent skin grafts when their wounds were fully granulating, which may have biased the time-to-closure results. Comparing the novel treatment (upholstery foam) to modern wound care, rather than to dry gauze, greatly contributed to the strength of the findings in this study. In addition, the investigators refrained from using antimicrobial topical agents under the foam dressings. However, because only the wounds of patients in the foam group were wrapped with an elastic bandage, it is possible the edema control provided by this intervention could account for some of the difference between groups. Also, the researchers autoclaved the foam, a process which is not replicable in many resource-limited environments.

**Food wrap.** In 2006, Takahashi et al.\(^{30}\) reported that because the Japanese health service system allows for the use of modern moist wound dressings for only 2 or 3 weeks, and many aged people with pressure ulcers take months to heal, pressure ulcers in Japan are still managed primarily with ointments and gauze. Based on case studies published by Toriyabe et al.\(^{31}\) in 1999, this group of researchers conducted a prospective open-label, nonrandomized controlled trial to determine if patient outcomes would improve when occlusive ordinary food wrap was used as the only treatment for Stage III and Stage IV pressure ulcers. The wounds of all 49 study patients were cleansed with saline. The 25 patients in the control group were treated with modern ointments containing iodine, enzymes, or SSD. Tunneling and undermining were packed with gauze to absorb excess exudate. The 24 patients in the experimental group had their wounds covered only with unsterilized polyvinylidene food wrap cut small enough to allow the exudate from the resultant autolytic debridement process to escape. When excess exudate was problematic, a thin paper diaper was added to protect the peri-wound skin. The frail health of the participants substantially impacted the study. Of the 49 patients in the initial evaluation, only 34 completed the full 12 weeks; nine control group patients died, seven test patients died, and two test patients were transferred to another hospital for treatment of unrelated severe illnesses. Healing scores were notably better for the food wrap group at each assessment, reaching statistical significance at weeks 8 and 12 (P <0.05). Eschar formation was also significantly less likely in the food wrap group (P <0.05). There was no difference in infection rates. Maceration, noted in three study patients (not statistically significant), resolved quickly when the size and shape of the test dressing was adjusted and did not prevent wound healing. This study was well-designed with a simple protocol, and the subjects were well matched. The use of the Japanese Society of Pressure Ulcers’ depth, exudate, size, infection, granulation, necrosis + undermining (DESIGN) scale to assess wound progress is logical for deep wounds; the more frequently used Pressure Sore Status Tool (PSST) or Pressure Ulcer Scale for Healing (PUSH) scores only provide a distinction between full- and partial-thickness wounds. The DESIGN scale is similar to the Bates-Jensen Wound Assessment Tool (BWAT), distinguishing between five levels of wound depth.\(^{32,33}\) The fact that no sterilization was utilized makes this protocol replicable by ordinary health practitioners. Limitations include the study was not blinded or randomized and the sample size was small. Although food wrap is affordable in all settings, it is not currently widely available in some developing countries, particularly in rural areas.

A 2012 article from a large group of researchers led by Bito et al.\(^{34}\) describes a study conducted in 15 hospitals in Japan comparing the use of food wrap to following Japan’s established modern moist wound therapy guidelines in patients with Stage II and Stage III pressure ulcers. Outcome evaluations of the 64-patient RCT were performed by wound experts using blinded digital images. Commercially available perforated food wrap with no packing or ointment was used to cover the wounds in the experimental group. PUSH scores were calculated at 2-week intervals until the study endpoint at 12 weeks. The study had a 5% dropout rate at 4 weeks, 23% at 8 weeks, and 36% by 12 weeks. No explanation for the high dropout rate was given; the dropout rate was comparable in both study groups. Stage II ulcers healed slightly more quickly in the conventional therapy group, while Stage III pressure ulcers healed more quickly in the food wrap group. Differences were not statistically significant. The authors warn that the fact the treatment could not be blinded could have influenced the care the patients received because wrap therapy is popular in Japan. Other study limitations were the small sample size, the high dropout rate, and the lack of wound closure as an outcome measure. This was a well-designed study with an experimental arm could be easily replicated in many developing country settings.

**Honey.** Honey has been used on wounds for many centuries.\(^{35}\) Honey’s high osmolarity prevents bacterial growth, decreases maceration, and encourages healing.\(^{36,37}\) Honey also continuously generates low levels of hydrogen peroxide, which inhibits bacterial growth without harming human tissue.\(^{37}\) All honey is not equally efficacious: the composition of honey is influenced by the species of bee and the plant origin of the nectar, as well as processing and storage procedures.\(^{36,37}\) The evidence does not support the use of honey in settings where early excision and grafting or commercial compression bandages are readily available, but it may be less expensive and more efficacious than other wound dressing materials available in villages.\(^{38}\)

Subrahmanyam (1996),\(^{39}\) of Solapur, India, compared highly viscous honey to BPP dressings in a prospective RCT of 100 patients with partial-thickness burns. All wounds were washed with sterile normal saline, then pure unprocessed local (Indian) honey was spread on the wounds of half the patients, while BPP dressings were applied on the remaining 50 patients. Wounds of both groups were covered
with dry sterile gauze and bandaged. Both dressing types were replaced every other day unless they were found to be leaking exudate. Pain relief was the same in both groups. Healing occurred significantly more slowly in the BPP dressing group. The authors reported that the high osmolality of the honey caused rapid “absorption” of edema fluid, which should speed healing. Highly viscous honey, which formed a physical barrier to prevent bacterial contamination of the wound, was used. Honey of this quality may not be available in rural areas of tropical developing countries. Study limitations include that the study was not blinded and the pain assessments were subjective evaluations by the staff.

Subrahmanyam also compared honey dressings to SSD in a 1998 prospective RCT of 50 patients with partial-thickness burns divided into two equal groups. Wounds of patients in both groups were cleansed with saline. Wounds in the experimental group were covered with a thick layer of pure, unprocessed, undiluted honey and covered with dry sterile gauze and bandages. Dressings were changed every other day. Wounds in the control group were covered with pieces of gauze that had been impregnated with SSD; these were changed daily. Evidence of infection, excessive exudate or leakage, and time to healing (using unspecified clinical and histopathological criteria) were recorded every other day. Cultures and biopsies were collected from all patients upon admission and on days 7 and 21. Clinical and histological data were evaluated, but no statistical analyses were reported. Subrahmanyam reported that wounds in the honey group healed faster, had superior histological results, and were more likely to have negative cultures at day 21. Strengths of this study include the prospective RCT design and that participants were approximately equal in demographics and wound characteristics at the onset of treatment. However, 60% of the wounds in the SSD group became dry with eschar formation, requiring surgical intervention and indicating that an insufficient quantity of SSD was applied to promote moist wound healing. Another limitation is that bandaging, which may enhance healing by decreasing edema through incisional compression, was reported as being performed only for the honey group. The study was not blinded.

Moore et al conducted a systematic review of human RCTs involving honey wound dressings. These reviewers found a high probability that honey is superior to all of the comparison topical treatments — ie, commercial polyurethane film, amniotic membrane, BPP dressings, and SSD. Only early tangential excision and skin grafting was superior to honey for burn wounds. However, reviewers reported that the quality of all of the studies, evaluated based on randomization, blinding, and reporting of withdrawals and dropouts, was very low (1 on a scale of 1 to 5). Validity scores ranged from 5 to 10 out of a possible 16. None of the studies was blinded, and only one study designated a primary outcome. None of the studies included chronic wounds. The same researcher (Subrahmanyam) conducted six of the seven studies. The reviewers called for more research on the use of honey in resource-limited areas, where cost and availability are critical issues in wound care. They warned that because honey is a natural product with varying wound healing characteristics, study results may not be generalizable to areas where available honey comes from other sources.

Affordable Methods of Wound Debridement

Autolytic debridement. Wound debridement is a problem in resource-limited environments, where surgeons and commercial debriding agents are scarce. Utilization of moist wound healing principles facilitates the natural breakdown of slough and wound debris by the body’s own enzymes and white blood cells, a process called autolytic debridement. In 1996, Martin et al conducted a double-blinded, prospective RCT in Leeds, England to determine the efficacy of autolytic debridement, comparing common lubricating jelly (KY Jelly, Johnson & Johnson, New Brunswick, NJ) with an identical-appearing enzymatic debridement ointment on 21 Stage IV pressure ulcers with black eschar. After the ointment was applied, all wounds were covered with a commercially available thin film dressing. Patients in the two groups were similar in age, wound duration, and co-existent illness. Eschar removal was faster in wounds treated with the lubricating jelly alone than in wounds treated with the enzymatic debrider, but differences were not statistically significant. The enzymatic debrider was 35 times more expensive than the lubricating jelly. This high-quality study was limited by a very small sample size. Lubricating jelly is available in many village markets, and in some settings, food wrap could take the place of the commercial thin film dressing.

In 2005, König et al reported on a 42-patient RCT, crossover design study comparing autolytic to enzymatic debridement for slough removal on chronic venous leg ulcer patients in Freiburg, Germany. One group used an inexpensive commercial dressing designed to promote autolytic debridement; the other used an enzymatic debriding ointment covered with gauze per manufacturer’s instructions. It is possible that the critical aspects of the commercial dressing (ie, a locally available foam product of a similar density, cut into dressings) could be improvised in the village setting to promote autolytic debridement. Patients changed their own dressings daily and applied short-stretch bandages to address their venous insufficiency. After 21 days, the 18 patients in the enzyme group and the six patients in the autolytic group who did not respond to the therapy received the alternate treatment. A difference in efficacy between the two treatments could not be shown. The researchers reported they were unable to recruit 58 patients (the computed number needed to reach statistical significance). Additional study limitations were the lack of blinding and the lack of objective measures used to assess debridement, which were particularly troubling because the study was sponsored by the dressing manufacturer, providing researchers with a motive to find in favor of the dressing. The
study could have been strengthened by using blinded experts to assess the digital photos of the wounds, which would dramatically mitigate the risk of bias.

**Papaya pulp.** Papaya pulp, which contains proteolytic enzymes commercially used in meat tenderizer and enzymatic wound debriders, is a readily available and inexpensive traditional wound treatment in the tropics. A qualitative, descriptive study\(^4^3\) on the use of papaya on pediatric burn patients in Banjul, The Gambia, found that infected or full-thickness burn wounds gradually become clean enough for grafting when papaya paste was applied. Patient comfort in the warm environment of the ward is enhanced because bulky or circumferential dressings are not needed: gauze secondary dressings adhere to the paste. The dressings must be soaked off with water. The researchers caution that papaya paste should not be used in partial-thickness wounds because they may be converted to full-thickness wounds by the papaya. This descriptive study provides detailed, useful information about a popular, traditional wound treatment.

**Sugar.** Edinburgh University Solution of Lime (EUSOL) has been used to kill wound bacteria and remove slough for decades, but it also damages granulation tissue and slows the healing process.\(^4^4\) Bajaj et al\(^4^4\) reported honey has been shown to be superior to EUSOL, but sugar is far cheaper and more readily available than honey. The authors compared applying sugar with a dry cover dressing to the wound bed to applying EUSOL-soaked dressings in a prospective RCT of 50 traumatic limb wound patients in Dharan, Nepal. Total wound area (measured using tracings on graph paper), “discharge,” and area covered with slough and granulation tissue were measured on day 1 and weekly thereafter for 4 weeks. EUSOL significantly outperformed sugar on all reported indicators. Study limitations include that many of the patients had compound fractures and that the sugar was not distributed evenly on the wound. In addition, patients in the EUSOL group had their wounds soaked for 30 minutes each day at dressing changes, while the patients in the sugar group did not. The sugar group also did not have the benefit of a moist wound dressing. Initial wound size, which could have been a confounding variable, is missing from the report, and the study was not blinded.

**Other Improvised Wound Treatments**

**Cryotherapy.** Acute anal fissures can develop as a result of constipation. Resultant ischemic ulcers can become chronic because the pain causes muscle spasms, which perpetuates the ischemia.\(^4^5\) A prospective RCT\(^4^5\) of 100 patients in New Delhi, India, with this wound type compared the addition of once-daily application of an icicle to the usual educational program, local anesthetic creams, laxatives, and sitz baths alone. The icicle was made by freezing a water-filled surgical glove with the fingers tied. It was inserted partway into the anus, where it acted as cryotherapy. The icicle lasted a mean of 7 minutes before melting and being expelled, and most patients were able to prepare and insert the device at home. The treatment period was 3 months for both groups. No complications occurred in either group. Pain scores (visual analog), bleeding episodes, and fissure healing at 2 weeks and at 3 months were dramatically better in the group using the frozen glove finger treatment. The treatment was believed to have promoted healing by breaking the pain-spasm-ischemia cycle. This well-designed, simple study showed that home cryotherapy can be useful. Solar, gas-powered, or electric freezers are sometimes available in resource-limited areas. The main study limitation was that the clinicians could have inadvertently provided superior support and education to patients in the frozen finger (intervention) group because they were not blinded.

**Topical negative pressure (TNP).** TNP is popular for controlling wound exudate and speeding wound contraction, but commercial devices are cost-prohibitive for patients in resource-limited environments.\(^4^6\) Mody et al\(^4^6\) compared an improvised TNP device utilizing wall suction and a locally constructed electronic controller to twice-daily, saline-soaked gauze dressings in a prospective RCT of 48 inpatients in Vellore, India, with major wounds. No differences were found between the two groups overall. Pressure ulcers closed significantly faster with the TNP device (\(P <0.05\)), which was less expensive than saline gauze. Strengths of this study include the use of a digital method of assessing wound closure, which increased objectivity, and the prospective RCT design. Limitations were that although patients reported TNP was painful, pain was not assessed; of the original 55 patients, 19 dropped out of the study early, and only the pressure ulcer patients were willing to continue TNP to wound closure; the surgeons who performed serial debridement on all patients were not blinded; the cost evaluation did not include caregiver time; and the comparison dressing was saline-soaked gauze, which does not usually stay moist between dressing changes. Although the improvised TNP device is far more affordable than commercial TNP devices, it still relies upon the availability of a complex controller, wall suction, and electricity.

**Summary and Evidence Assessment I**

Published evidence for wound management methods available in resource-limited environments is extremely limited. However, the 18 articles reviewed suggest that BPP dressings are superior to gauze and that banana leaves are superior to both BPPs and petrolatum gauze. Polyurethane, saline-soaked furniture foam, and food wrap also may be effective moist wound dressings. Papaya pulp, some varieties of honey, EUSOL, and lubricating jelly also may be efficacious, affordable substances for treating and debriding wounds. Papaya pulp can be unsafe if not very closely monitored. TNP can be achieved with ordinary wall suction. Ice can be a useful tool in wound healing, at least with anal fissures. Many of the most promising improvised wound management methods rely at least partially on autolytic debridement.
Most of the dressings described in the literature were autoclaved, and the tested TNP device requires continuous electricity. The International Energy Agency reports that 1.44 billion people live without electricity, including more than 40% of the people who live in Sub-Saharan African cities. It is doubtful that any wound treatment that depends on electricity can be broadly utilized in developing countries. All of the published studies describe wound care performed by health professionals based in urban hospitals. Many of the studies took place in temperate environments, and only one took place in Africa. These studies may not uniformly generalize to the hot climates with extremes in humidity found in resource-limited rural areas of tropical developing countries, where health professionals are absent.

Some clinicians practicing in resource-limited environments have responded with innovation to the need for affordable moist wound treatments for their patients, but few have published well-designed comparison studies. No studies comparing sustainable moist wound management methods with current wound management practices in villages were found. In fact, only a few of the studies reviewed here describe interventions that could be made widely available to lay health practitioners in rural areas of tropical developing countries. The results of this literature

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<td>Prasannababy</td>
<td>2000 India</td>
<td>Banana leaves are better than paraffin gauze on burn donor sites</td>
</tr>
<tr>
<td>Gore and Akolekar</td>
<td>2003 India</td>
<td>Banana leaves are better than BPP on partial-thickness burns</td>
</tr>
<tr>
<td>De Buck and Van de Velde</td>
<td>2010 Review</td>
<td>Banana leaves are the same as using BPP on burns</td>
</tr>
<tr>
<td>Sopata et al</td>
<td>2002 Poland</td>
<td>Simple foam dressings are the same as using hydrogels on Stage II and Stage III pressure ulcers</td>
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<tr>
<td>Varma et al</td>
<td>2006 India</td>
<td>Saline-soaked furniture foam is better than modern dressings or ointments + gauze on lower limb wounds</td>
</tr>
<tr>
<td>Takahashi et al</td>
<td>2006 Japan</td>
<td>Unsterilized food wrap is better than ointments + gauze on pressure ulcers</td>
</tr>
<tr>
<td>Bito et al</td>
<td>2012 Japan</td>
<td>Perforated unsterilized food wrap is the same as following modern wound management guidelines on Stage II and Stage III pressure ulcers</td>
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<tr>
<td>Subrahmanyam</td>
<td>1996 India</td>
<td>Honey is better than BPP on partial-thickness burns</td>
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<tr>
<td>Subrahmanyam</td>
<td>1998 India</td>
<td>Honey is better than SSD on partial-thickness burns</td>
</tr>
<tr>
<td>Moore et al</td>
<td>2001 Review</td>
<td>Honey is better than polyurethane film, amniotic membrane, BPP, SSD; early grafting is better than honey (review)</td>
</tr>
<tr>
<td>Martin et al</td>
<td>1996 England</td>
<td>Lubricating jelly is better than an enzymatic debrider on Stage IV pressure ulcers with eschar</td>
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<tr>
<td>König et al</td>
<td>2005 Germany</td>
<td>Commercial dressing is the same as using enzymatic debrider on chronic venous ulcers</td>
</tr>
<tr>
<td>Starley et al</td>
<td>1999 The Gambia</td>
<td>Papaya is an effective debrider, with cautions</td>
</tr>
<tr>
<td>Bajaj et al</td>
<td>2009 Nepal</td>
<td>EUSOL is better than table sugar in traumatic limb wounds</td>
</tr>
<tr>
<td>Chintamani et al</td>
<td>2009 India</td>
<td>Frozen glove section is better than no frozen glove section for treating anal fissures</td>
</tr>
<tr>
<td>Mody et al</td>
<td>2008 India</td>
<td>Homemade TNP is better than no TNP for treating major wounds</td>
</tr>
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BPP = boiled potato peel dressings  
SSD = silver sulfadiazine cream  
EUSOL = Edinborough University Solution of Lime soaked dressings  
TNP = topical negative pressure
review confirm observations by other wound experts. In a 2003 article, Pieper and Caliri discuss the lack of evidence for three nontraditional wound treatments commonly used in Brazil: sugar, papaya/papain, and fatty acids. Bolton, a strong advocate for moist wound healing, has drawn attention to the need for more research into innovative solutions for resource-limited environments in two issues of WOUNDS in 2010.

II. Current Wound Management Practices in Villages

Lay healthcare providers in rural areas of tropical developing countries need to be taught how to provide safe, efficacious, affordable wound care. The first literature search reported here provides data for creating sustainable wound management protocols using improvised, inexpensive materials. However, not one of the studies was conducted in remote rural settings where VHWs and THPs perform most wound care. The results of studies of wound care performed by health professionals in temperate climates may not translate to the tropical village setting. Therefore, before implementing a teaching program, proposed protocols should be tested in the tropical village setting to establish ecological validity.

When the author considered designing an experimental study to validate proposed wound management protocols including sustainable dressings such as banana leaves, it quickly became apparent that the “usual practice” control group was indeterminate. Therefore, a second literature review was conducted to answer the research question, “What are the topical wound management interventions currently being used in rural areas of tropical developing countries?”

Completely unrestricted PubMed searches in November 2012 for articles including current usual wound management practices in rural areas using (developing countries [MeSH Terms] OR Africa OR India) AND ((wound* AND skin) OR pyoderma OR (ulcer* AND skin) OR pustule* OR (sore* AND skin) OR (lesion* AND skin)) AND (rural OR village* OR remote) yielded 244 articles. Articles specific to diseases that cause only superficial rashes or skin pigment changes were excluded. Every remaining article was obtained and combed for any mention of topical wound management in rural areas of tropical developing countries. Most of the articles did not include any content related to the topic. A CI-NAHL search in November 2012 using the parameters from the PubMed search with “not in PubMed” as the only limit yielded 225 additional books, articles, conference poster presentations, and the like. All identified publications that might contain pertinent information were obtained and scanned for enlightening references (an ancestry search), which also were obtained and read.

Perhaps as a reflection of the fact that the lay health workers who manage wounds in rural and remote areas have little ability to publish their work, no articles with detailed descriptions of wound management practices in villages were found. However, the search process yielded three survey reports with brief descriptions of some aspect of usual wound management in villages, six ethnobotanical articles with tables including wound treatments, and four research studies on wound care interventions in rural areas of tropical developing countries. Because these articles could provide additional information to guide the design of research studies in this field, all 13 are reviewed here.

Brief Descriptions in Survey Reports

A 1993 epidemiological study of burns in Ethiopia included a survey of burn knowledge among villagers. Although the purpose of the study was to identify the causes and possible ways to prevent burns in the village setting, details about first aid for blistering or more severe burns (larger than a chicken egg) were included by the researchers. Although villager first aid always included applying some substance to the burned area, only 30% of the 163 villagers surveyed would apply either cold water (23%) or a clean cloth (7%), which are the only first aid treatments the authors recommended. Butter or oil (47%), egg yolk (39%), or milk (5%) were the least harmful substances the villagers applied. Courtright et al acknowledged that egg yolk might be slightly helpful. They reported that 15.9% of the respondents, mostly older males, stated they would apply a clearly deleterious substance to the burn wound, including dirt (7%), cow dung (4%), unspecified traditional compounds (4%), or salt (2%). Among patients taken to the hospital (after an average of 7 days), 32% had “undeniably” been subjected to detrimental traditional topical treatments. This study was limited to a brief description of first aid, without details about further wound management. However, it provided a list of substances used on burns.

Arikpo et al included several similar lists of treatments used by villagers on wounds in their study of self-medication in rural Nigeria. Despite a low literacy rate in the study area, the reported response rate on the structured written questionnaire for randomly selected participants was 75%, for a total of 552 responses. The authors state, “herbs, antibiotics, ash, kerosene, petrol, etc” were used to treat any of 16 health problems, including four types of wounds, with no specific drugs used for specific ailments. Folk remedies described included “a mixture of traditional substances such as herbs, lime, honey palm kernel oil, etc., and modern industrial products such as medicated ointment, alum, antibiotics, etc.” The only available choices for treatment habits on the survey were “doctor” or “self-medication.” Almost all (99%) of the respondents answered “self-medication” for all 16 ailments. The researchers reported that 10% used ointments to treat a sore throat, while 0.0% used ointments for wounds and cuts. The questionnaire was not published. Although it is likely that the example remedies are used to treat health problems in this setting, the results suggest that the structured, written questionnaire may have been a poor study design choice for this setting.
Landier et al’s Buruli Ulcer prevention study in Cameroon also discusses a few specific wound management techniques in tropical villages. This survey relied on verbal interviews to evaluate participants’ activities and health habits, including their methods of wound first aid. Landier et al found that participants who reported using alcohol or soap to cleanse minor wounds were less likely to develop Buruli Ulcers, participants who did nothing for minor wounds were more likely to develop Buruli Ulcers, and cleansing minor wounds with leaf sap, ground tablets purchased in the market, or ointment was neutral. Applying a cloth or adhesive bandage was protective only if the bandage was changed at least weekly, while leaving the wound open to air was associated with an increased risk of developing Buruli Ulcer. The interviewers used a closed-ended questionnaire; washing with plain water or salt water was not listed among the responses. The study focused on the use of bednets and occupational activities and did not discuss usual wound management practices of villagers, but it did support the idea that education of VSCs can influence wound outcomes.

These three studies are useful in that they provide lists of possible choices for usual wound management in rural areas of tropical developing countries. However, they do not give detailed descriptions, and each focuses on only one small geographical area.

**Ethnobotanical articles.** Although THPs are sometimes reluctant to share their knowledge of medicinal plants, many published papers by ethnopharmacologists have catalogued plants used by THPs and VSCs in various rural areas of developing countries. No published studies that evaluated the efficacy of any wound treatment performed by THPs were found. Only six studies were found describing how plants and other local materials are used by villagers to treat wounds. These studies all provide tables listing plant names, parts used, method of preparation (poultice, powder, decoction), and ailment(s) (including wound type, when applicable) for which each plant is indicated. However, none of the studies included wound bed preparation, wound coverings, or any details of wound treatment.

**Intervention studies.** The largest of the four wound intervention studies was a 5-year dermatology project reported on by Schmeller in 1998 and by Schmeller and Dzikus in 2001. VHWs in rural western Kenya were taught to identify and treat common skin diseases in approximately 5,000 children from 13 schools. Gentian violet paint (1%) was used on bacterial skin infections, wounds, and tropical ulcers. When 1999 skin disease rates were compared to 1993 pre-intervention statistics, the researchers found no significant reduction in the prevalence of dermatitis, scabies, and bacterial infections and a significant increase (P < 0.05) in the prevalence of fungal infections. Schmeller and Dzikus reported a distinct reduction in the extent and severity of skin diseases in 1999 when compared to 1993, but this was not quantified. They also reported a 10-fold decrease in tropical ulcers, along with an increase in impetigo. The researchers concluded that the expensive school project yielded few long-term benefits to the community. Therefore, modern wound management principles would justify its use on superficial skin diseases but not on deep wounds such as ulcers. Although gentian violet paint would quickly be diluted by wound exudate in a tropical ulcer — Robinson et al report that tropical ulcers are often up to 2 cm deep — it is possible the treatment prevented some cases of impetigo from developing into deep lesions.

Desai et al reported on a 1-day intervention carried out in a rural area of India to decrease the incidence of scabies, pediculosis, ringworm, and pyoderma in 1985. Twenty-five VHWs diagnosed 1,787 patients out of a population of 17,019; the team then treated pyoderma with oral antibiotics and topical gentian violet paint. Scabies and pediculosis were treated directly by the VHWs with lindane. The researchers concluded this was an effective method for decreasing the incidence of scabies and pyoderma in epidemic situations, but the intervention was too cost-prohibitive for routine control of these diseases.

Lehman et al reported in 2003 that pyoderma prevalence rates as high as 70% in the remote Australian Aboriginal population were associated with an alarming rate of chronic renal failure due to glomerulonephritis. Following the opening of a swimming pool in an Aboriginal community in the Northern Territory, a reduction in skin infections was reported. The chlorinated swimming pool water may have served as a topical disinfectant. Swimming pools were built in two remote Aboriginal communities in Western Australia in hopes their use among schoolchildren would decrease the prevalence of pyoderma and otitis media. After 2 years of the swimming pool intervention, pediatric pyoderma rates in the two communities had fallen from 70% and 62% to 20% and 18%, respectively, and the severity of pyoderma cases also declined. Funds were not available to expand this intervention to other communities.

A 1975 article by Belcher et al reports that when researchers studying guinea worm disease in Ghana found only 0.5% of the sufferers had gone to clinics for their wounds, they taught some of the villagers to perform self-care. The 69 patients who were given antibiotics and instructions for cleaning, soaking, and dressing wounds by the researchers were disabled for an average of 2.4 weeks, as compared to disability for 5.3 weeks among the controls.

None of these four intervention studies discuss usual wound management practices utilized before the researchers’ interventions, and none of the interventions was sustainable long-term. More affordable solutions are needed to solve the wound problem in rural areas of tropical developing countries.

**Discussion**

The 78% of the world’s population living in resource-limited environments need evidence-based, safe, effective,
affordable wound care. Wound management experts are beginning to recognize this need. However, at this point, so little is known about current usual wound management practices in rural areas of tropical developing countries that a comparison trial cannot be designed. More rigorous research in this area is critical. Natural products (see Figure 2) used commonly in villages should be included in these trials. Lindbald\(^73\) cautions that efficacy studies must be carefully designed to distinguish between the pharmacological benefits of these products and their biophysical benefits. Occlusive or viscous herbal products may be interchangeable if their benefits are entirely the result of their promotion of moist wound healing.\(^71\)

**Conclusion**

Although very little research has been done on sustainable wound management methods that can be utilized in rural areas of tropical developing countries, some information was available in the literature. Banana leaf dressings, saline-soaked furniture foam, and food wrap all can be used as moist wound dressings. Efficacious, affordable substances for promoting autolytic debridement have been identified as well. No studies describing current usual wound management practices in villages or comparing introduced practices in this setting were found. However, several lists of possible choices for usual wound management in rural areas of tropical developing countries were obtained.

The next step in the translational research process is to describe the current usual wound management practices in rural areas of tropical developing countries so experimental studies with a valid control group can be designed. The author conducted the first detailed descriptive study of usual wound management practices in villages throughout Ghana in 2012 and expects to replicate it in Central Africa and Asia in the near future. The author also is evaluating plastic bags used in village markets to determine if they may be good substitutes for food wrap. The indigenous nonprofessional health providers who care for wound patients in rural areas of tropical developing countries need evidence, and this evidence can be obtained with carefully designed studies. \(^\)

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