

Research Article

Wound Irrigation Using Normal Saline 0.9% Versus Tap Water: A Review for Street Medicine and Low-resource Providers

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Abstract

Patients experiencing homelessness are a vulnerable cohort who suffer from disproportionate skin disease burden. Acute and chronic wounds represent high morbidity conditions with severe consequences. Adequate management in the form of cleansing and irrigation is necessary for removing cellular debris, bacteria and contaminants. Providers in low-resource street medicine settings may be the first point of contact in the management of wounds encountered by unhoused patients. This review determines the feasibility of improvised irrigation techniques that can be used in street settings to irrigate wounds. A MEDLINE search was conducted and yielded randomized controlled trials, laboratory studies and case-control studies. No significant difference in wound infection and healing rates was found when normal saline 0.9% or tap water was used in wound irrigation. Improvised cleansing devices with suitable irrigation pressure included water bottles punctured with 14-18-gauge needles, 10-mL syringes and 50-syringes. Lower and upper extremity wounds were found to be at higher risk of infection, requiring judicious management and cleaning. Street medicine providers should consider weighing the benefits versus risks of on-site, improvised wound irrigation for acute soft tissue injuries, especially in the setting of limited resources.

Keywords: Irrigation; Wound Care; Homeless; Street Medicine

Introduction

Patients Experiencing Homelessness (PEH) are a population at high risk for acute and chronic wounds [1]. Without regular access to primary care, PEH are often forced to receive basic medical care at hospital Emergency Departments (ED) [1]. Previous studies in emergency room settings show that timely, proper wound irrigation is a protective factor against wound infection [2,3]. However, North American hospitals have found no appreciable difference in wound infection

rates when irrigation is performed with tap water versus normal saline 0.9% [4]. In fact, best practices for irrigation are mostly undecided in terms of fundamental guidelines [5]. There is even less data surrounding how to best treat wounds outside of a traditional hospital setting. Since it is known that proper irrigation can prevent infection, the knowledge gap can have an impact on PEH population wound infection rates. Street medicine is a relatively new field whereby clinicians evaluate and treat PEH on the streets in the context of harm reduction [6]. A bridge that can connect unsheltered PEH from the street to the clinical setting are street medicine providers, who can provide basic checkups, medications and wound care. Since timely cleaning of wounds is paramount to the healing process and prevention of infection, this is important for street medicine providers, as it can decrease morbidity and complications among PEH. Additionally, practitioners in low-resource settings often require cost-effective solutions to manage the health needs of PEH. Treatments with similar efficacy as the current standard of care but with a lower

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cost can free up funding for additional health services to be provided to PEH. As such, a comparison of available literature can guide practitioners about the risks versus benefits of cleansing wounds with bottled water versus normal saline 0.9% in a street environment. Therefore, we conducted a literature review to evaluate among patients treated in community or emergency settings, whether wound irrigation with tap or bottled water in improvised devices resulted in more infections or ineffective cleansing compared to medical grade, sterile normal saline 0.9%.

Material and Methods

A MEDLINE search was performed with articles from January 1990 to April 2022. Included were the following terms: (Street OR Unsheltered OR Homeless OR Rough sleeper) AND (Wound irrigation OR Skin cleaning OR Wound care) AND (Infection) AND (Outcome). Studies were restricted to the English language. Original research, case reports, physician reports and textbooks were evaluated to see if they met at least 2 of the 4 following inclusion criteria: (i) evaluation of wounds encountered in community or non-clinical settings; (ii) wound care performed in a non-hospital setting; (iii) wound interventions with sterile normal saline 0.9%, tap water or bottled water (iv) wound outcomes and/or infections; The studies were not limited by setting (e.g. hospital vs in the field etc.) and included clinical data. The PRISMA scoping review checklist was used to guide the research protocol [7,8]. The checklist is attached as supplemental materials. The MEDLINE search had a total of 354 results. Three reviewers completed the initial review to see if they met criteria. An additional scoping review on Cochrane Library and Google Scholar produced a further 10 articles that met inclusion criteria. All relevant data was then compiled in an Excel spreadsheet.

Results

Article Selection and Quality Assessment

After the first round of reviews, 251 articles were excluded as they did not pertain to the research questions. Upon second read 33 more articles were excluded for not meeting at least 2 of the 3 inclusion criteria. The total number of articles included was therefore 39 (Fig. 1).

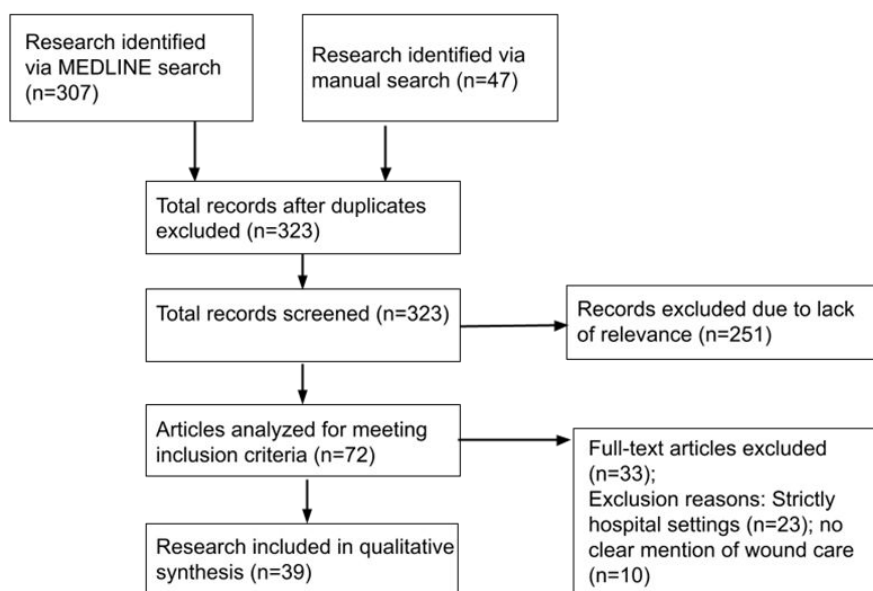


Figure 1: Flow diagram of article selection.

Wound Definition

Primary literature had varying definitions for the term wound. Some definitions included wounds from surgical defects or traumatic origin, whereas others referred to them being caused by pathologic etiology like infections. A wound is formally described as damage to biological tissue integrity. In the context of our study, a wound is epithelial disruption secondary to trauma, disease or environmental factors (Table 1) [2,3].

Study Year (Author)	Setting	Intervention	Outcomes		Significance (p≤0.05 considered significant)
		Wound cleansing/irrigation			
2016 (Chan) [9]	Hong Kong homes	with sterile normal saline 0.9% (control) versus	No difference between normal saline 0.9% and tap water for:		
		tap water			
		(experimental)			
			Baseline wound characteristics:	Acute vs Chronic	p=0.26
				Ulcer Stage	p=0.06
				Wound Location	p=0.47
			Wound infection and outcomes:	Infection	p=0.49
				Inflammation	p=0.49
				Decrease in wound size	p=1.00
				New epithelialization and granulation	p=0.23
			2001 (Griffiths) [10]	Australian metropolitan community health centers	Wound irrigation with sterile normal saline 0.9% (control) versus tap water (experimental)
Infection rates		p>0.05			
Healing rates		p>0.05			
			No clinical differences in infection rates when comparing irrigation with normal saline (n=271) versus tap water (n=259) for:		
2003 (Valente)	U.S. urban pediatric emergency department		Simple laceration irrigation with sterile normal saline 0.9% (control) versus running tap water(experimental)	Acute wound infection rates	2.8% infectionsin normal saline group (95% **CI 1.1 to 5.7%) compared to 2.9% in running tap water group (95% CI 1.2% to 5.9%)

U.S.		Wound irrigation sterile normal saline 0.9% (control) versus tap water (experimental)	Tap water or normal saline for irrigation before closure of lacerations had equivalent outcomes for:	
2007 (Moscati)	multicenter, including community emergency department		Acute wound infection rates	11/334 (3.3%) infections in saline group compared to 12/300 (4%) in tap water cohort. RR =1.21 (CI 0.5-2.7)
			Tap water (n=318) versus normal saline (n=313)had no significant differences in outcomes for:	
2013 (Weiss)	U.S. community emergency department	Wound irrigation using either sterile normal saline 0.9% (control) versus tap water (experimental)	Acute wound infection rates	20 infections noted in normalsaline group (6.4%, 95% CI 3.7% to 9.1%) compared to 11 infections in the tap water group (3.5%, 95% CI 1.5% to 5.5%).
	UK	Wound lavage comparing sterile water (control) to novel aqueous oxygen peroxide (experimental)	For chronic venous leg ulcerations, no significantdifference in healing at	
			8 weeks	p=0.979
2014 (O'Halloran)	multicenter, Primary care-based clinics		12 weeks	p=0.263
			For chronic venous leg ulcerations, significantimprovement in healing over control at	
			6 months	p=0.014
			12 months	p=0.006
**CI = Confidence interval; *OR = Odds Ratio				

Table 1: Randomized controlled trials and case-control studies describing wound outcomes, differences in irrigation and risk factors for infection.

Chan, et al., compared wound characteristics such as ulcer stage, location and chronicity in a home-health setting when wound care was performed with normal saline 0.9% versus tap water for 22 subjects having 3- wounds. Patients were provided regular wound care, with wound assessment every week for 6 weeks. No statistically significant difference was noted in wound characteristics between interventions. Furthermore, wound outcomes such as infection, size and epithelialization were found to have no significant difference in the tap water and normal saline 0.9% patient cohorts. One limitation (apart from the limited sample size) is the lack of longitudinal follow-up past 6 weeks, especially since many of the wounds encountered were chronic and would likely persist for much longer. Similarly, Griffiths, et al., demonstrated no significant difference in healing or infection rates, when over a six-week period, 35 patients with 49 wounds were irrigated with either normal saline 0.9% or tap water in community health centers in Australia. The small sample size was a major limitation, especially since numerous patients had multiple wounds. Valente, Moscati and Weiss were emergency department-based studies where acute wounds and lacerations were irrigated with normal saline 0.9% or tap water. There was no statistically significant difference in acute wound infection rates any of the three studies which were conducted in community, urban and suburban emergency departments with sufficient sample sizes (more than 500 participants per study). Follow-up timeframe ranged from 5 to 14 days in some studies and 48 hours to 30 days in others. Major limitations included a lack of follow-up (up to 10% in some cases) as well as a lack of blinding among physicians, who were able to notice the irrigant being used. O'Halloran focused mostly on chronic venous wounds and found that a novel irrigation solution (aqueous oxygen peroxide) may have improved long-term healing (past 6 months) of consistent use, but shorter-term healing parameters were unchanged compared to sterile water. Limitations include unclear complete

methodology as well as potential conflicts of interest being sponsored by the device manufacturer. As such, tap water or sterile water may certainly have favorable cost-to-benefit ratios in the short term for acute wounds, but the outcomes for chronic wounds are more uncertain (Table 2).

Study Year (Author)	Setting/Study Type	Outcomes		
2016 (Luck) [12]	Experimental laboratory study	No difference between commercial wound irrigation device (4-5 psi)and:	Punctured water bottle with14G needle (7-25 psi)	
			10 mL syringe + 14G catheter (14-24 psi)	
			Water bottle with sports top (3-7 psi)	
		Not able to achieve pressures of commercialwound irrigation device:	Plastic bag punctured with14G needle (2-3 psi)	
			Bladder-style irrigation system (1-2 psi)	
1998 (Morse)	Clinical Trial	Improvised devices for irrigation evaluated (as compared to standard wound irrigation devices) in an emergency department setting.		
			30 mL syringe/18- ga 1.25in. catheter	8.16 PSI
		Appropriate irrigation pressure for:		
			30 mL syringe/19- ga needle	7.33 PSI
		Inadequate irrigation pressure for:	1,000 mL plastic bottle and cap	1.50 PSI
			1,000 mL IV bag and port	2.01 PSI
2006 (Fellows) [13]	Home-health/Quasi-experimental	Saline solutions can be prepared via table salt in distilled water; remained bacteria free in refrigerator 1 month (n=15)		
		Bacillus and pseudomonas grew after 1 week in opensaline at room temperature (n=6)		
1997 (Riyat)	Experimental study in emergency department and homes	Tap water samples collected from different emergencydepartment areas as well as nearby homes were analyzed twice for growth of coliform, <i>Staphylococcus</i> , <i>Clostridia</i> , <i>Pseudomonas</i> and <i>Streptococcus</i> species.Analysis of tap water showed no pathogenic bacteria isolates, although saprophytic species were present.		
(Selim) [15]	Community nursing2001 organization/Pilot project	No significant findings/no clear consensus on tap watervs saline being preferred for community-based wound management		

2003 (Lammers) Prospective [16] observational cohort study		Mean wound age for uninfected group was 4.4 hr vsinfected group 5.7 hr (<i>p</i> <0.05)	
		Wound locations with higher infectionrates:	
		Thigh/leg	23%
		Arm/forearm	15.3%
		Foot/toe	12.5%
		Chest/abdomen	11.8%
		Wound locations with lower infectionrates:	
		Face	3.9%
		Scalp	1.7%
		Ear/nose	3.6%
2016 (Resende) Cross-sectional		Microbial colonization after wound irrigation with sterile normal saline 0.9% versus tap water	
	randomized study	No significant difference in overall colonization of:	Gram-positive, Gram- negative bacteria and fungi
		Colony-forming unit discordance in:	Gram-positive bacteria (significantly reduced after tap water irrigation)
2020 (Dohoo) [11]	Homeless shelter/Case-controlstudy	Increased risk of *GAS infection for	
		Younger patients	<i>p</i> =0.01 <i>OR</i> **=9.1(<i>CI</i> 1.57-52.9)
		Previous wounds or conditions	<i>p</i> <0.01 <i>OR</i> =59.2 (<i>CI</i> 2.73-1160)
		Wounds without care or irrigation	<i>p</i> <0.01 <i>OR</i> =77.4 (<i>CI</i> 7.38-812)
		Reduced risk of GAS infection for:	
		Wounds with care and irrigation	<i>p</i> <0.01 <i>OR</i> =51.5 (<i>Ci</i> 8.86-299)
*GAS = Group A Streptococcus			

Table 2: Experimental, observational and other studies describing wound outcomes, differences in irrigation and risk factors for infection.

The experimental studies by Luck, et al., found punctured water bottles with a 14-gauge needle, a 10-mL syringe with a 14-gauge catheter and a water bottle with a sports top had similar irrigation pressures compared to a commercial wound irrigation device [12]. Potential issues include the lack of standardization in syringes, catheters and needles, many of which may have different ergonomics that could impact the force applied. This was similar to the study by Morse which found similar devices to have appropriate irrigation pressure among acute wounds encountered [37]. Fellows, et al., assessed self-prepared nonsterile saline solutions and found that such solutions could remain bacteria-free up to one month in a refrigerator [13]. However, at room temperature, the same solutions grew bacillus and pseudomonas species after one week. On the other hand, Riyat found growth of saprophytic species in tap water isolates in an emergency department, but no direct growth of pathogenic organisms [39]. In terms of preference for using normal saline 0.9% or tap water in a community setting, Selim, et al., conducted a survey on a large community nursing organization, mostly composed of nurses providing wound-care in a home-health setting [15]. They found no established consensus on the preference of tap water versus normal saline 0.9% among home healthcare nurses, many of whom noted no appreciable difference in subjective patient outcome. Lammers, et al., characterized wound infection rates as a

function of anatomic location as well as wound age [16]. Lower extremity wounds, particularly on the thighs (23%), arms (15.3%) and feet (12.5%) were noted to have comparatively increased wound infection rates than the face (3.9%), nose (3.6) or scalp (1.7%). Resende, et al., directly cultured wounds after irrigation with either normal saline 0.9% or tap water. Even though the colonization character (such as total species) was unchanged with either intervention, the overall numbers of bacterial species were lower after irrigation. Additionally, there was a modest reduction noted in colony-forming units of gram-positive bacteria compared to the normal saline 0.9% cohort. The only study conducted in a homeless shelter by Dohoo, et al., noted an increased risk of Group A *Streptococcal* infection among patients lacking wound care (including irrigation) compared to those with wound care [11]. Additionally, younger patients and those with a history of previous wounds or medical conditions had an increased risk of developing wound infections.

Per our search, no high-quality studies exist on wound infection rates in a street medicine setting. Studies also evaluate wounds that have been sutured, not necessarily wounds that were irrigated and dressed with gauze, which are the expected lesions on the street [20]. These studies were also conducted indoors and in controlled environments [17,18]. Guidelines for wound management in low-resource practices are even more sparse. Since most street medicine practitioners are volunteers and have limited funding, they must often improvise with whatever equipment is present at the time [21]. Additionally, the trials which were conducted in community settings were still quite different from street evaluations of patients, where the environment is significantly less controlled. Emergency medicine physicians have described preliminary recommendations for wound irrigation that can be employed in the field [22]. This includes puncturing a bottle of sterile water, normal saline 0.9% or sealed drinking water with an 18-20-gauge needle multiple times (Fig. 2,3). The field irrigation could then use a larger volume to adequately cleanse wounds with a low infection risk.

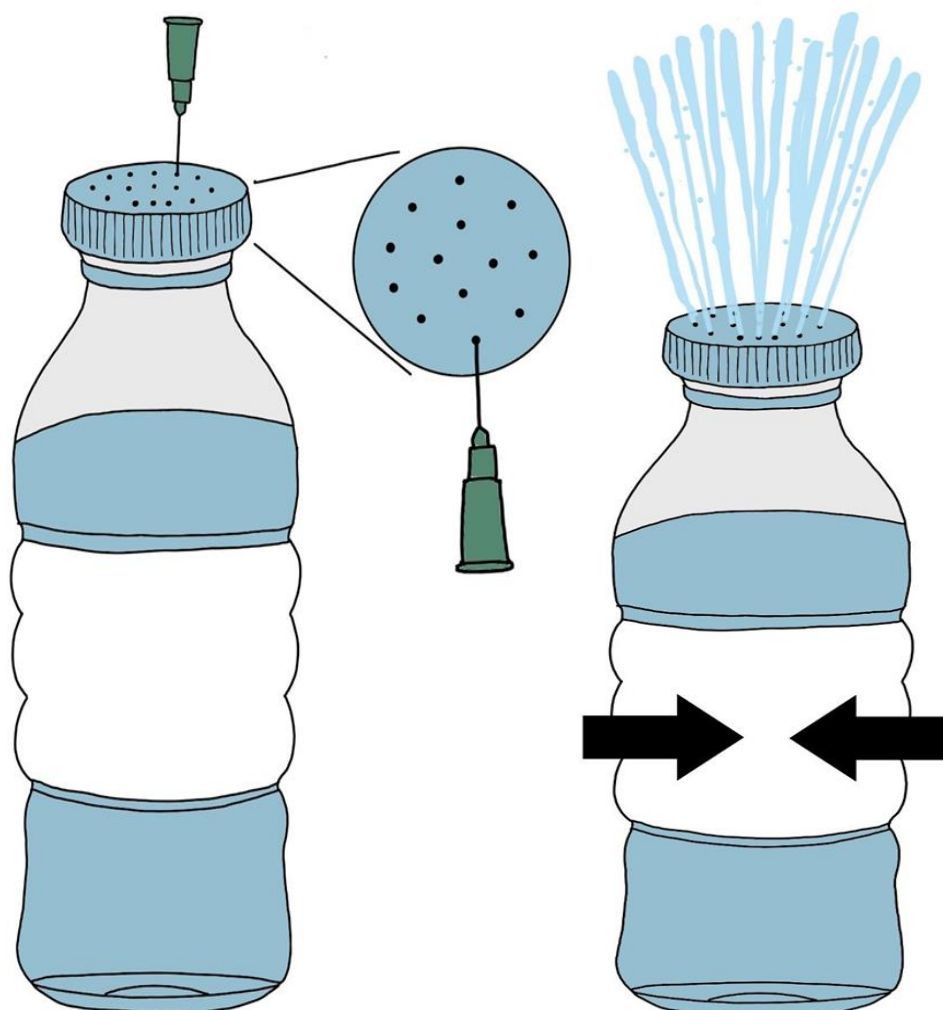


Figure 2: Puncturing cap of water bottle approximately 12-18 times with 14-18-gauge needle. The variable pressures achieved during irrigation with such a device range from 7-25 psi, on par with or above recommended wound irrigation pressures.

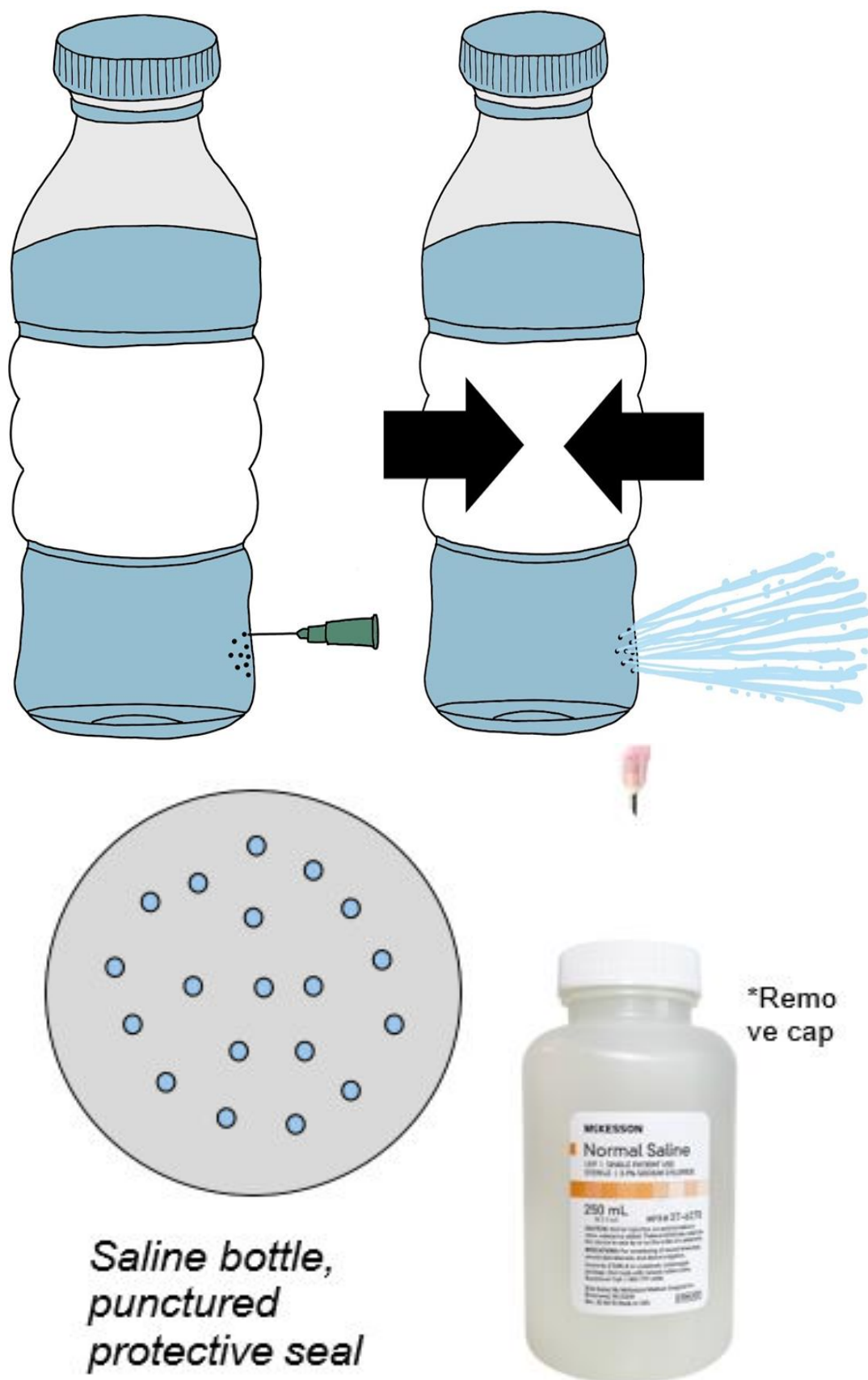


Figure 3: Puncturing the side of a water bottle with a needle similar to Figure 2. This method has less-established findings of appropriate irrigation pressure but has been used extensively by emergency department physicians [22].

Only studies in clinical environments evaluated the effect on temperature on wound cleaning. Angeras, et al., found a statistically significant reduction in infection rates when traumatic, superficial soft-tissue wounds were cleaned with warm tap water (5.4%) compared to cold normal saline 0.9% (10.3%, $p < 0.05$) [30]. Another study by Ernst described significantly increased patient comfort in the use of warmed normal saline 0.9% compared to room temperature normal saline 0.9% when irrigating laceration wounds (95% CI 5.7-63, $p < 0.05$) [31].

Discussion

Overall Benefits of Wound Irrigation

Wound irrigation is essential for proper wound care, especially in the early stages of acute wounds [9]. Fluid irrigation has multiple beneficial effects such as the removal of contaminants, bacteria and cellular debris. No clear benefit was established for the use of normal saline 0.9% in wound irrigation compared to tap water, even in non-clinical community settings (Table 1). However, most studies demonstrated low power and poor study quality. There was no standardized definition of what constitutes wound irrigation. According to certain guidelines, every centimeter of wound should have 50 mL of liquid irrigation [17]. Furthermore, studies evaluating irrigation pressure noted 12-15 psi (pounds per square inch) to be optimal for reducing bacterial count and minimizing tissue trauma [18,19]. The improvised punctured water bottle after wiping with alcohol, (on the cap) using 14-gauge needles was noted to have variable pressure (7-25 psi), likely due to the fluctuating squeezing motion when dispensing fluid. One solution noted is using a higher volume of fluid to offset the variable pressure and provide adequate irrigation [17]. Acute wounds or epithelial disruption should generally be irrigated unless there is an actively bleeding wound, as the irrigation may dislodge any clots being formed [17]. However, for severely traumatic wounds, such as those including exposed bone or tendon, sterile normal saline 0.9% is generally preferred, which should be followed by hospital evaluation [20].

Although there is no definitive consensus on the effect of tap water on acute wound infection and healing, community studies have demonstrated that it may be a cost-effective and efficacious wound irrigant. Most of the studies conducted had limited power and study quality, meaning that it is an avenue for further and more definitive research. This is also true for the realm of street medicine, as acute wound management parameters are not well understood. Since pre-emptive wound management prevents complications, street outreach-based wound care could reduce ED visits by addressing the immediate needs of PEH before major complications develop. Wound irrigation devices improvised in the field such as water bottles with puncture holes can be one of the many tools used in resource-limited settings to provide timely wound care [12,22].

Commercial water is often sold in individual 500 mL bottles, so each bottle could be used entirely per patient. This would also reduce the risk of cross-contamination and be significantly more cost-effective than similar volumes of sterile normal saline 0.9%. Emergency medicine physicians have described using 18-20-gauge needles to puncture (10-20 times) the side of water bottles as an irrigation device for wounds with low infection risk [22]. This may be simpler than puncturing the thicker plastic on the bottle cap, as instability could inadvertently cause needlestick injury to the operator. However, there has been no clear indication as to the pressure generated by using the side of the bottle for irrigation.

Additional Considerations for Acute Wounds Encountered

Bite wounds from humans or animals or contaminated lower extremity wounds may require surgical debridement (in addition to tetanus or rabies prophylaxis), so providers must also be ready to refer patients to formal clinical settings in the case of complicated lesions [20]. Tap water used in the aforementioned studies is potable (drinkable) due to treatment such as chlorination. It would likely not be appropriate for wound care in developing countries or regions lacking adequate water treatment infrastructure [9].

It is worthwhile to wear eye protection during the irrigation process, especially in a street setting, due to the higher frequency of transmissible diseases like hepatitis C [25]. While hepatitis C transmission via wound-splashing into the eye is rare and has only been described in a few case reports, the benefits likely exceed the inconvenience to the operator [26]. After appropriate cleansing, it is important to remove excess moisture by gently pressing with gauze or a cloth followed by dressing with non-adhesive gauze [19]. Acute wounds have improved healing in moist environments, but excessive moisture can cause maceration around wound edges [27].

Wound Irrigation for PEH

PEH are often unable to follow-up appropriately so additional wound dressings and supplies should be provided for them to change throughout the healing process [29]. Another consideration is the level of expertise of the wound care provider. The studies were conducted in community settings, but the wound cleaning was performed mostly by nursing staff or physicians [9,12]. Even so, there was a lack of standardization both in terms of the type of cleansing as well as the skill level of the person performing the care [14,15]. Street medicine settings often use physician and medical student volunteers, so the wound care parameters may not necessarily translate from the literature to the street [6,21].

The differences in wound infection rates by anatomic location mean that irrigation and cleansing should preferentially be performed on the upper and lower extremities, when applicable [16]. Chronic wound status and advanced patient age can be used to stratify care, as Lammers also noted a statistically significant increase in infection risk in such cohorts [16].

A vital consideration for the use of improvised equipment in the care of PEH may lead to perceptions of providing substandard care [32]. To the best of our knowledge, there has been no peer-reviewed, published consensus of patient satisfaction with care received by Street Medicine teams and the use of modified water bottles and improvised irrigation devices instead of more 'clinical' apparatus could be additionally perceived as unwelcome or discriminatory [33]. Utmost care must be taken to communicate efficiently and clearly with patients, informing them of the adequacy of treatments dispensed, as well as answering any concerns that may arise.

Conclusion

There is no significantly increased risk of infection or delayed healing in acute wounds when irrigating with potable tap water compared to sterile normal saline 0.9%. This is primarily due to imperfect data and a lack of consensus among different studies and trials. A suitable level of pressure is required for appropriate wound irrigation which can be achieved by water bottles punctured with 14-18-gauge needles. Appropriate wound cleansing and management may help prevent infections in acute wounds. Street medicine providers in low resource settings can consider using improvised irrigation equipment in the absence of standard clinical devices, especially for acute soft tissue wounds.

Conflict of Interests

The authors declare that they have no known competing financial interests, personal relationships or other conflicts of interest in this paper.

Declarations

The views and opinions expressed in this presentation are those of the authors and do not necessarily reflect the official policy or position of the University of Miami Health System nor the Miami Street Medicine Organization. The recommendations are based on contemporary literature as well as preliminary data from homeless health outreach programs. They are not meant to be substitutes to actual clinical guidelines.

Ethical Approval and Consent to Participate

Not applicable.

Consent for Publication

The authors hereby consent to the publication of our Work in any and all publications.

Availability of Data and Materials

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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Authors' Contributions

Taha Rasul: Manuscript preparation, central thesis development, literature evaluation, manuscript drafting, data analysis.

Orly Morgan: Manuscript structuring, editorial correction, content structuring and correction, data analysis.

Daniel Bergholz: Final paper evaluation and content management.

Dr. Hadar Lev-Tov: Direction of paper, specific details of wound irrigation, etc. (needs to be amended)

Armen Henderson: Advised thesis development and literature review guidelines.

Samrah Mitha: Manuscript preparation, literature evaluation and manuscript drafting.

Sameer Akhtar: Manuscript drafting.

Umair Sultan: Manuscript drafting.

Anna Davis: Manuscript drafting.

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