The effectiveness of cleansing solutions for wound treatment: a systematic review

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Executive summary

Background

The management of chronic and acute wounds has changed significantly over the last decade.The practice of wound cleansing or antiseptic management has a dichotomous history anchored in tradition and science.

Although there is a consensus that wound cleansing reduces infection rates, there is, however, some debate in clinical circles about the potential advantages and disadvantages of cleansing wounds. This practice may not always be necessary as the exudate itself may contain growth factors and chemokines which contribute to wound healing.

Objectives

The objective of this review is to identify and synthesize the best available evidence on the effectiveness of cleansing solutions for wound treatment in clinical practice and compare the effectiveness of different cleansing solutions in infection and wound healing rates.

Inclusion criteria

Types of participants

This review considered studies that included patients with chronic and acute wounds (of any etiology), with the exception of obstetric wounds. Patients aged 18 years or more in any setting (hospital, community and general practice) were included, with the exception of malnourished patients.

Types of intervention(s)

This review considered studies that used any cleansing solution or chemicals as cleansing solutions other than antiseptic solutions in wound treatment.

Types of studies

This review considered experimental study designs including randomized controlled trials (RCTs), non-randomized controlled trials, or other quasi-experimental studies, including before and after studies.

Types of outcomes

This review focused on two types of outcomes: primary outcome (infection rate) and secondary outcome (healing rate).

Search strategy

An initial search of MEDLINE and CINAHL was undertaken, followed by a second search for published and unpublished studies from January 1990 to January 2013 in major healthcare-related electronic databases. Studies in English, Spanish and Portuguese were included.

Methodological quality

Methodological quality was assessed by two independent reviewers using the standardized critical appraisal instrument from the Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instrument. Two independent reviewers assessed seven studies. There was general consensus among the reviewers to include the three final studies in this review.

Data collection

Data were extracted using the JBI data extraction form for experimental studies and included participant characteristics, intervention characteristics and study methods.

Data synthesis

The impact of interventions on infection and healing rates was described in a narrative format within each intervention. Data from two studies were pooled in a meta-analysis.

Results

Eight studies met the inclusion criteria. From those, five studies were excluded after assessment of methodological quality. The remaining three original articles, which consisted of 718 patients, were included in this review. The three studies were randomized clinical trials. The

interventions included in this systematic review were: Tap water versus Sterile saline and Povidone-iodine-soaked gauze versus Saline-soaked gauze.

Data from two studies reporting the effectiveness of Tap Water versus Sterile Saline and respective wound infection rates were pooled in a meta-analysis. The meta-analysis showed a low heterogeneity (Heterogeneity Chi squared=1.45, p=0.23; I^2=31.1%). No statistically significant differences were found (z=0.59; p=0.55). Nevertheless, a positive effect in the prevention of infection rates was observed in the tap water group (OR=0.79; 95% CI: 0.36, 1.72). For acute wounds, the odds ratio of developing an infection when cleansing with tap water compared with saline was 0.98 (95% CI: 0.43, 2.25).

Conclusions

There is no evidence that using tap water to cleanse acute and chronic wounds in adults increases infection or healing rates. There is some evidence that it reduces infection when compared to saline. There may be a trend towards a lower wound infection rate when povidone-iodine is used in surgical wounds, but this was not significant for varicose vein surgery.

However, due to the small number of studies by interventions (few cleansing solutions), the evidence is not strong enough to produce a best practice.

Keywords

cleansing solutions; wound; systematic review; meta-analysis

Background

The management of chronic and acute wounds has changed significantly over the last decade. The practice of wound cleansing or antiseptic management has a dichotomous history anchored in tradition and science.[1] It is an integral part of the management of both acute and chronic wounds.[2, 3]

Although there is a consensus that wound cleansing reduces infection rates[2] there is some debate in clinical circles about the potential advantages and disadvantages of cleansing wounds. This practice may not always be necessary as the exudate itself may contain growth factors and chemokines which contribute to wound healing.[3,4] Until further research establishes its demerits, cleansing will continue to remain an integral part of the wound management process. Despite this, there is a lack of strong evidence to indicate that cleansing wounds per se increases healing or reduces infection.[5, 6]

This reality is also intensified by the lack of a diagnostic test which would allow healthcare professionals to identify the bacterial load in the wound that is capable of causing wound infections. In addition, the situation is further complicated by studies showing that bacterial colonization of the wound does not necessarily indicate infection and that there is no need to remove bacteria in the absence of clinical signs of infection.[2]

Nevertheless, several studies have recommended various cleansing agents for their supposed therapeutic value. It has also been suggested that wound cleansing helps to optimize the healing environment and decrease the potential for infection.[7,8] It loosens and washes away cellular debris such as bacteria, exudate, purulent material, and residual topical agents from previous dressings.[9,10]

However, in practice, the decisions on which cleansing solutions to use have been based on experience, service policy and personal preference.

In general, the characteristics of an ideal wound cleansing solution are: non-toxic to human tissues; remains effective in the presence of organic material; reduces the number of micro-organisms; causes no sensitivity reactions; is widely available; is cost-effective; and is stable with a long shelf life.[11]

Normal saline fulfills all the criteria given above. Normal saline (0.9%) is the favored wound cleansing solution because it is an isotonic solution and does not interfere with the normal healing process, damage tissue, cause sensitization or allergies or alter the normal bacterial flora of the skin (which would possibly allow the growth of more virulent organisms).[5,10,12-15]

Tap water is also recommended and has the advantages of being efficient, cost-effective and accessible.[5,16] There is now increasing recognition of the safe use of tap water for wound irrigation, especially chronic wounds[15], and it is worth considering it as an acceptable alternative to other products. Indeed, Flanagan[11] argues that water has been used for centuries to treat wounds without any reported detrimental effects. Despite this, the two most commonly cited concerns regarding tap water are the possible infection risk and the fact that it is not an isotonic solution.

In this matter, several studies have found no significant difference between the infection and healing rates in wounds irrigated with normal saline or tap water.[8,16,17] In fact, Angeras et al.[16] found a higher infection rate in those wounds irrigated with saline. However, clinicians have been cautioned against using tap water to cleanse wounds that have exposed bone or tendon, in which case normal saline is recommended.[5,18]

On the other hand, there is no consensus amongst wound care authorities on the advantages of using sterile solutions over non-sterile solutions.

Research has also established that the use of antiseptic solutions may compromise the healing process[19] and, as a result, the use of normal saline as a cleansing solution is widely recommended.[13]

In fact, preparations with antiseptic properties have also been traditionally used since the earliest times; however, published research has suggested that antiseptic solutions may hinder the healing process. For this reason, several guidelines and various studies discourage the use of antiseptic solutions, such as povidone iodine, hydrogen peroxide, or sodium hypochlorite, because, in most instances, they do not effectively promote good wound healing. In contrast, most studies showed that their use impaired wound healing, reduced wound strength, or increased infection.[14,20]

The controversy surrounding the use of antiseptics prompted the development of guidelines for the use of antiseptics by wound care experts. These guidelines have also resulted in changes in hospital practice.[5] Concerns are also mounting relating to the use of these products, and the development of bacterial resistance and the possible systemic absorption of antiseptics. In most cases, the selection of these products does not have a solid scientific basis.

Still, new cleansing solutions are emerging. Most recently, the new cleansing solution based on polyhexanide and betaine has emerged as a credible alternative to currently available products.[21-23] This particular solution is effective for treating colonized/infected wounds, providing optimal conditions for wound healing, reducing healing time, signs of inflammation and/or infection/colonization, and

providing greater odor control. It has a painless application and is especially indicated for the treatment of chronic and hard-to-heal wounds.[21,23-25]

An extensive literature review identified several systematic reviews and best practice guidelines. However, despite these publications, rigorous research is still needed to support the identified recommendations.[5,14,23]

Remarkable advances have been made in wound care and treatment. Despite this, numerous factors impact on this science; thus managing wounds will continue to be a healthcare concern. Increased life expectancy, frequency of wound development among older people, increased prevalence of diabetes, and considerable monetary and lifestyle costs make the appropriate cost-effective management of wounds an international healthcare imperative. Both acute care and community-based nurses are in a unique position to provide evidence-based education and interventions to their peers and consumers. Thus, the purpose of this systematic review is to investigate the effectiveness of cleansing solutions for wound treatment in clinical practice.

Objectives

The objective of this review is to identify and synthesize the best available evidence on the effectiveness of cleansing solutions for wound treatment in clinical practice and compare the effectiveness of different cleansing solutions in infection and wound healing rates.

More specifically, the review focused on the following questions:

Does the effectiveness of different cleansing solutions influence infection and wound healing rates?

Which cleansing solution is more effective for reducing wound infection rates?

Which cleansing solution is more effective for increasing wound healing rates?

Is the effectiveness of cleansing solutions affected by wound etiology?

Inclusion criteria

Types of participants

This review considered studies that included patients with chronic and acute wounds (of any etiology), with the exception of obstetric wounds. Patients aged 18 years or more in any setting (hospital, community and general practice) were included, with the exception of malnourished patients.

Types of intervention(s)

This review considered studies that used any cleansing solution or chemicals as cleansing solutions other than antiseptic solutions in wound treatment.

For this purpose, we compared the effects of the following cleansing solutions on the healing and infection rates in acute and chronic wounds (may include, but not be limited to):

- Tap water compared with normal saline
- Water (distilled and/or cooled boiled water) compared with sterile normal saline
- Tap water compared with cooled boiled tap water
- Tap water compared with polyhexanide/betaine solution

- Tap water compared with any other solution
- Sterile normal saline compared with polihexanide/betaine solution
- 0.5% or 2% Chlorhexidine Gluconate(CG)
- 70% alcohol
- Povidone-iodine
- Any other comparable solution emerging in scientific papers.

Types of studies

This review only considered experimental study designs including randomized controlled trials, non-randomized controlled trials, or other quasi-experimental studies, including before and after studies.

Types of outcomes

This review considered studies that included the outcomes “infection rate” and “healing rate”.

In this regard, this review focused on two types of outcomes:

1) Primary outcome (infection rate)

2) Secondary outcome (healing rate).

Both analyses were divided into three groups:

1) Acute wounds

2) Chronic wounds

3) Wounds with specific etiology.

Search strategy

The search strategy included both published and unpublished studies. A three-step search strategy was used in this review. An initial limited search of MEDLINE and CINAHL was undertaken, followed by an analysis of text words in the titles and abstracts and the index terms used to describe the article. A second search using all identified keywords and index terms was then undertaken across all included databases. Thirdly, the reference list of all identified reports and articles was searched for additional studies. Studies published in English, Spanish and Portuguese were considered for inclusion in this review. The search strategy per database encompassed the period between January 1990 and January 2013.

The searched databases were:

CINAHL Plus with Full Text, MedicLatina, Academic Search Complete, MEDLINE with Full Text, Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, Nursing & Allied Health Collection: Comprehensive (via EBSCO);

LILACS;

Elsevier - Science Direct (via b-on – Online Knowledge Library);

Embase;

Scopus;

JBI Library;

ACP online;

BioMed Central;

Health Technology Assessment database;

Scielo - Scientific Electronic Library Online.

The search for unpublished studies were include:

'Grey Literature Report' from New York Academy of Medicine;

Mednar;

Scirus.com website;

National Library of Australia's Trove service;

ProQuest – Nursing and Allied Health Source Dissertations;

Banco de teses da CAPES (www.capes.gov.br);

RCAAP – Repositório Científico de Acesso Aberto de Portugal.

The first English keywords used were:

Water, sodium chloride, polihexanide, clean*, wound*, heal*, infect*, detergents, povidone-iodine, chlorhexidine, hydrotherapy, shower, bath, irrigate

Method of the review

Papers selected for retrieval were assessed by two independent reviewers for methodological validity prior to inclusion in the review, using standardized critical appraisal instruments from the Joanna Briggs Institute System for the Unified Management, Assessment and Review of Information package (SUMARI) (Appendix II). Any disagreements between the reviewers were resolved through discussion, or with a third reviewer (as originally outlined in the review protocol).[26]

Data collection

According to the predefined criteria in the review protocol,[26] Data were independently extracted from the papers included in this review by two reviewers, using standardized data extraction tools from the Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI) (Appendix III). The data extracted included specific details about the interventions, populations, study methods and outcomes of significance to the review question and specific objectives. Due to missing information or data that needed to be clarified, the authors of primary studies were contacted. Any disagreements between the reviewers were resolved through discussion, or with a third reviewer.

Data synthesis

Quantitative data were, whenever possible, pooled in statistical meta-analysis using JBI-MAStARI. All results were subject to double data entry. Effect sizes were expressed as odds ratio (for categorical

data) and weighted mean differences (for continuous data), and their 95% confidence intervals were calculated. Heterogeneity was statistically assessed using the standard Chi-square. Plausible explanations for variations in treatment effects were explored using subgroup analyses, whenever possible, so as to specify population and intervention differences and the quality of the studies. Where statistical pooling was not possible, the findings were presented in narrative form, including tables and figures to aid in data presentation where appropriate.

Deviation from the protocol

The databases/search engine searched covered both published and unpublished studies. Thus, a search on the Agency for Healthcare Research and Quality (AHRQ) was not performed. The search strategy per database should have encompassed the period between January 2000 and January 2013. However, the search in databases included the period from January 1990 to January 2013 so that relevant studies published before 2000 were also included.

Results

Description of studies

The search identified 5346 potentially relevant studies. Of these, 2089 were excluded as duplicates; of the remaining 3257, 3160 were excluded after title and abstract assessment; 89 out of the 97 remaining articles were excluded for not fulfilling the inclusion criteria after full text reading. The methodological quality of the remaining eight studies was assessed. Finally, a total of three original articles, which included 718 patients, were included in this review. See Figure 1 for the process described above. The three studies were randomized clinical trials.[8,17,27] The timeframe for the included studies was 2001-2013.

Additional information about the venue/country where the study was developed was requested by two authors of two included studies.[8,27]

One study was conducted in Buffalo and Minneapolis in the USA[8]; one was a study in New South Wales, Australia[17]; and the remaining study were conducted in Hobart, Australia.[27]

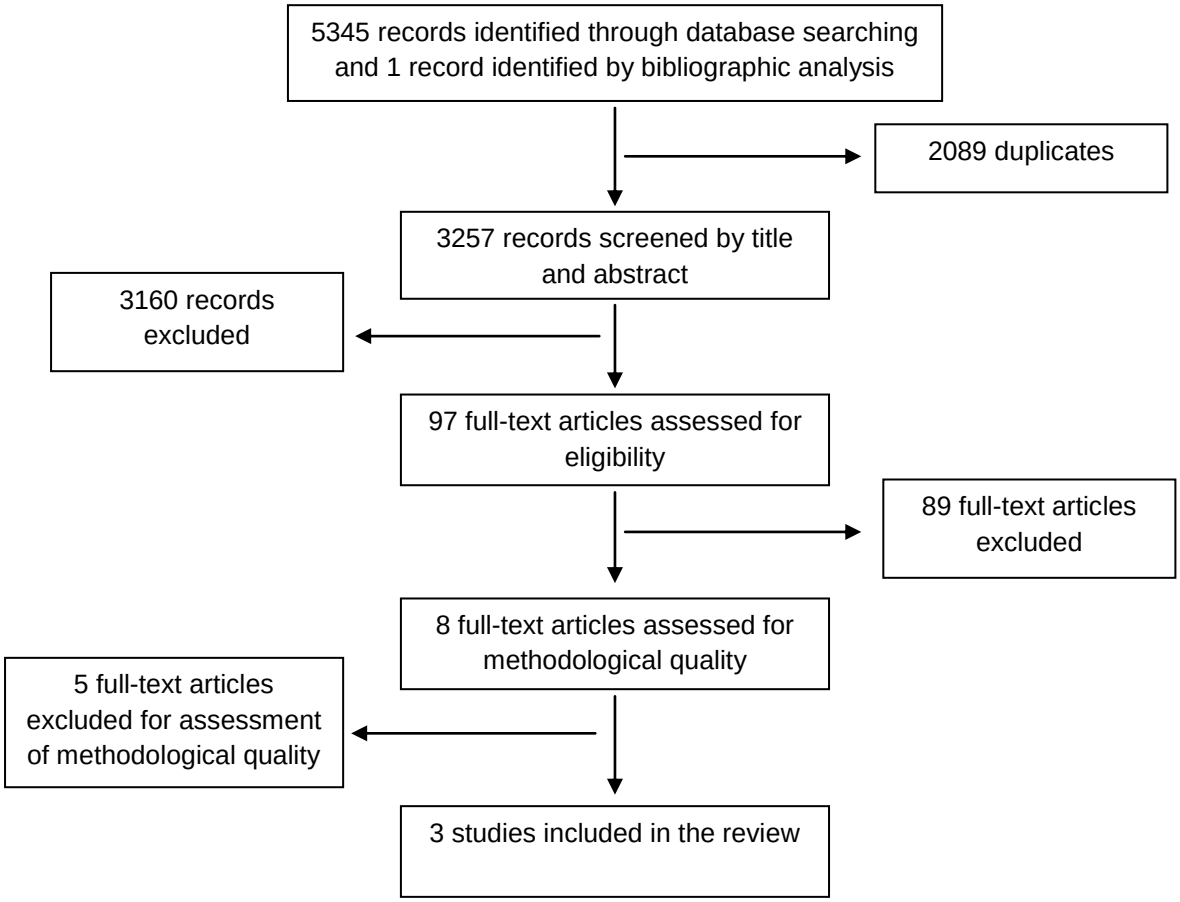

Figure 1: Flowchart for the search and study selection process

Methodological quality

Cut-off point for inclusion of a study in the review: the reviewers established that the studies had to receive a "yes" answer to at least six questions in the standardized critical appraisal instrument from the JBI-MAStARI to be included in the review.

Two independent reviewers assessed the seven studies. There was general agreement among the reviewers to include the three final studies in this review. Two studies[8,27] demonstrated similarity at baseline between both groups (experimental and control) related to participants' demographic characteristics. Sample sizes of the studies included in this review ranged from 35 to 634 participants. Details of included studies are presented in Appendix IV.

Four studies were excluded after thorough review and analysis of methodological quality. The list of excluded studies and the reasons for exclusion are presented in Appendix V.

The information related to true randomization is always unclear. Participant blinding was unclear[27] or not addressed[8] in two studies.

Only limited data were able to be combined in meta-analysis due to the variations between studies.

MAStARI

Table 1: Number of included and excluded studies

Number of studies included	Number of studies excluded
3	5

Table 2: Randomized controlled trial/pseudo-randomized trial

Citation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
[8] Moscati et al., 2007	U	N	Y	N	U	Y	Y	Y	Y	Y
[17] Griffiths et al., 2001	U	Y	Y	Y	Y	U	Y	Y	Y	Y
[27] Walker and Smith, 2013	U	U	U	N	Y	Y	Y	Y	Y	Y
%	0.00	33.33	66.67	33.33	66.67	66.67	100.00	100.00	100.00	100.00

Y = yes; N = no; U = unclear

The effectiveness of cleansing solutions for wound treatment

In this section, we summarize the results of the three included studies by solutions in wound treatment: tap water versus sterile saline and povidone-iodine-soaked gauze versus saline-soaked gauze.

Details related to the methods, participants' characteristics, interventions and conclusions of the included studies are presented in Appendix IV.

Tap Water versus sterile saline

Acute simple lacerations

Moscati et al.[8] developed a multicentre, prospective, randomized trial to compare wound infection rates for irrigation with tap water (n=300) versus sterile saline (n=334) before closure of wounds in the emergency department. The study was conducted at two Level 1 urban hospitals and a suburban community hospital with a sample of 634 adults presenting with acute simple lacerations requiring sutures or staples. Twelve (4%) subjects in the tap water group had wound infections, compared with 11 (3.3%) in the saline group. The results showed equivalent rates of wound infection using either tap water or sterile saline.

Acute and chronic wounds

In a double-blind randomised controlled trial, Griffiths et al., (2001)[17] investigated the effects of tap water and normal saline on the healing and infection rates of acute and chronic wounds. The trial was conducted in two metropolitan community health centres in New South Wales, Australia. Thirty-five patients with 49 acute or chronic wounds were randomized to receive wound irrigation with either normal saline (n=26) or tap water (n=23). The results demonstrated there was no significant difference between the infection and healing rates in wounds irrigated with normal saline or tap water.

Povidone-iodine-soaked gauze versus saline-soaked gauze

Walker and Smith (2013)[27] developed a prospective, randomised, blinded, controlled trial to assess the effect of povidone-iodine (betadine) on the groin wounds of patients undergoing primary varicose vein surgery. Forty-nine patients were recruited. Thirty-seven groin wounds were randomized to saline-soaked gauze and 32 groin wounds were randomized to Betadine. There was a reduced incidence of groin wound infections in those randomized to Betadine (three versus one), but this was not statistically significant (P = 0.4). This study supports the use of povidone-iodine in reducing wound infections, a particular problem in vascular surgery, and especially procedures in the groin area.

In Table 3 the conditions of the wounds and patients by study are described. These are important impact factors that should be considered to understand the infection and healing rates of the wounds.

Table 3: Conditions of the wounds and patients by study

Study	Wounds conditions	Patients conditions
[8], Moscati et al., 2007	Patients with puncture wounds, bite wounds, self-inflicted wounds, wounds more than eight hours old, wounds involving tendon, joint or bone, wounds with gross contamination requiring scrubbing or surgical debridement were excluded.	Patients taking antibiotics or corticosteroids, diabetic patients, patients with significant peripheral vascular disease, with human immunodeficiency virus or other immunocompromised conditions were excluded.
[17], Griffiths et al., 2001	Patients with acute or chronic non-sutured wounds (grade II or III) according to Carville's definition were included. On Grade II, wounds had partial thickness skin loss down to the epidermis and/or dermis, while grade III wounds had full-thickness skin loss down to, but not through, the fascia.	Patients with co-morbidities such as diabetes were included those who were immunosuppressed due to therapies such as chemotherapy and taking antibiotics were excluded.
[27], Walker and Smith, 2013	-	Patients undergoing primary saphenofemoral ligation for varicose veins associated with skin changes (C4–6 in the Clinical, Etiologic, Anatomic, Pathophysiologic [CEAP] classification) were included. Patients were excluded if they had an allergy to iodine; were planned to undergo redo groin dissections for recurrent varicose veins; patients having varicose vein surgery that did not involve a groin incision; all patients received a preoperative dose of low-molecular-weight heparin as thromboembolic prophylaxis. No prophylactic antibiotics were used.

Results of the meta-analysis of quantitative research findings

Only two[8,17] of the three studies included in data synthesis were eligible for meta-analysis, in a total of 683 patients.

Both studies assessed the effectiveness of tap water versus sterile saline and compared wound infection rates. However, Griffiths et al.[17] also presented the healing rates. In each study, intervention and control groups were compared at baseline and both studies were similar. The only relevant difference between studies was the wounds etiology. Due to this variation, we performed a meta-analysis by subgroups (Figure 2) and the test for subgroup differences showed a low heterogeneity (heterogeneity Chi squared=1.45, p=0.23; I^2=31.1%), whereby the meta-analytic integration of studies can be accepted.[28,29]

For acute wounds, the odds ratio of developing an infection when cleansing with tap water compared with saline was 0.98 (95% CI: 0.43, 2.25).

Tap water was more effective than saline in reducing the infection rate in adults with acute and chronic wounds (OR= 0.14; 95% CI: 0.01, 2.92).

The overall analysis estimated that there are no statistically significant differences (z=0.59; p=0.55) between cleansing with tap water and with sterile saline regarding wound infection rates in acute and chronic wounds. Nevertheless, we can still point out that there was a beneficial effect on the tap water group regarding the prevention of infection rates which is supported by the meta-analytic results (OR=0.79; 95% CI: 0.36, 1.72).

It should also be noted that the study of Moscati et al.[8] has a higher weight (77.6%) than Griffiths et al.[17] (22.4%).

Meta-analysis

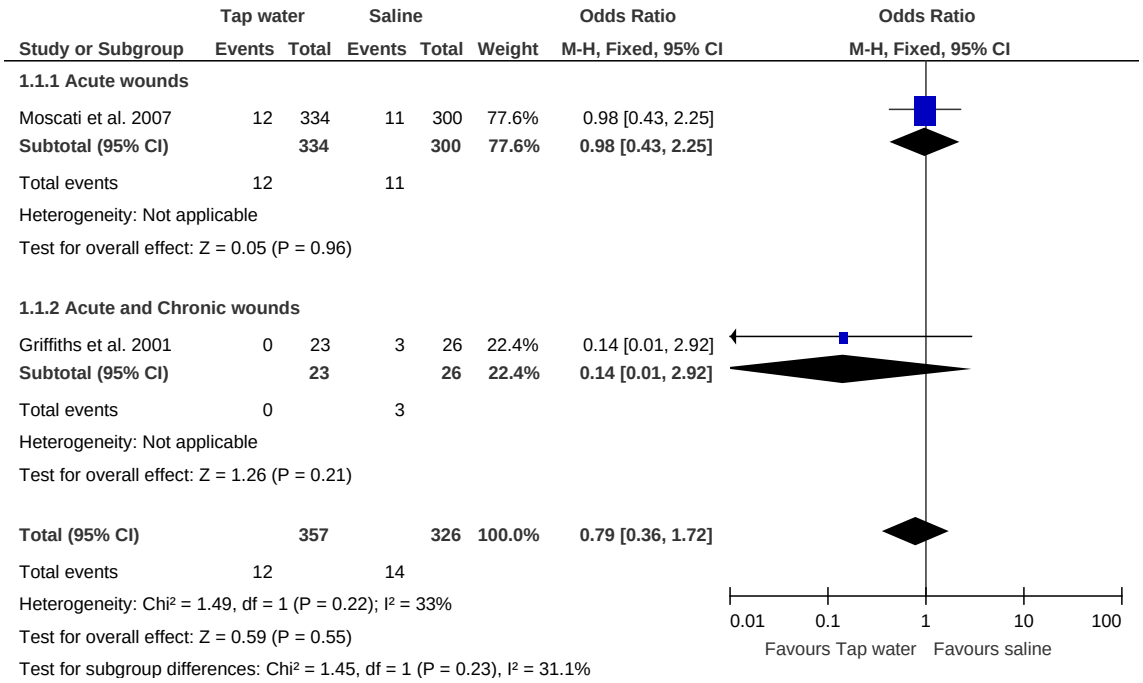

Figure 2: Forest plot of tap water versus sterile saline on the infection rates of acute and chronic wounds

The answers to the review's questions are presented, by study, in Table 4. All studies provided results related to the main review question "Does the effectiveness of different cleansing solutions influence infection and wound healing rates?" However, there are some results related to other review questions, as described in table 4.

Table 4: Answers to the review's questions presented by study

Study	Does the effectiveness of different cleansing solutions influence the infection and wound healing rates?	Which cleansing solution is more effective for reducing wound infection rates?	Which cleansing solution is more effective for increasing wound healing rates?	Is the effectiveness of cleansing solutions affected by wound etiology?
[8], Moscati et al., 2007	Twelve (4%) subjects in the tap water group had wound infections, compared with 11 (3.3%) in the saline group. The results showed equivalent rates of wound infection using either tap water or sterile saline.	Compared with sterile saline, tap water for wound irrigation is more cost effective and appears to be equally safe and efficacious. Tap water should be considered in emergency departments as a reasonable alternative to sterile saline for wound irrigation.	Healing rates were not an outcome of this study. No evidence.	The results allowed no conclusions.
[17], Griffiths et al., 2001	The results demonstrated that there was no significant difference between infection and healing rates in wounds irrigated with normal saline or tap water.	Although there was no statistically significant difference between healing and infection rates in the wounds from both groups, tap water can be considered a safe and cost-effective alternative.		
[27], Walker and Smith, 2013	There was a reduced incidence of groin wound infections in those randomized to Betadine (3 versus 1), but this was not statistically significant (P = 0.4). This study supports the use of povidone-iodine in reducing wound infections, a particular problem in vascular surgery and especially procedures in the groin area.	Although there may be a trend towards a lower wound infection rate when povidone-iodine is used in surgical wounds, this is not significant for varicose vein surgery.	Healing rates were not an outcome of this study. No evidence.	

Discussion

This systematic review found three clinical trials confirming the effectiveness of cleansing solutions for wound treatment. These solutions were: tap water versus sterile saline and povidone-iodine-soaked gauze versus saline-soaked gauze.

Excluded studies by search strategy and assessment of methodological quality reported other solutions used for wound cleansing: super-oxidized solution, 2% hydrogen peroxide, 2% chlorhexidine gluconate, polyhexanide (phmb), and betaine.[21] Thus, for these particular solutions, further strong and well-designed RCTs are needed to examine the effects on the wound itself and the effectiveness on various types of wounds.

The included studies showed that there was no statistically significant differences between the healing and infection rates in the wounds cleansed with tap water or normal saline.[8,17] Therefore, tap water can be considered a safe and cost-effective alternative. They also showed that there might have been a trend towards a lower wound infection rate when povidone-iodine was used in surgical wounds, but this was not significant for varicose vein surgery.

However, data analysis regarding wound infection was difficult due to a lack of consistency in the criteria used to assess wound infection. In addition, variance data for the healing outcomes were only reported in one study.[17] The use of a standardized and validated tool for the measurement of wound infection and healing and an assessor blinded to the intervention would have enhanced the accuracy of the trials and strengthened the evidence. In the future, other outcomes such as patient comfort, pain and satisfaction should be measured. We recommend that these variables be included in the studies' protocols.

Another important issue was cost management because the availability and cost of resources could also have determined which solution was used for cleansing wounds in different settings. So this was an increasingly important issue in all aspects of health care. In this matter, the study of Moscati et al.[8] showed that tap water was more cost-effective than saline and that could help to reduce the potentially significant cost of wound care.[17] Using tap water could also have reduced the risk of body fluid contamination due to splattering as it did not require the provider to be in close proximity to the patient during the irrigation process.[8]

Another limitation was the low sample size in two of three included studies[17,27] and the lack of data about power analysis and effect size to provide information on the magnitude of the intervention's impact. Thus, a small sample size could have led to an underestimation of the treatment's effectiveness. All of these weaknesses could have limited the synthesized process and the results of this systematic review.

In this review, we only included articles published in English, Portuguese and Spanish. Thus, articles published in others languages could also have been important to this review and this was another limitation.

As previously stated, the meta-analysis was only possible in two studies. Nevertheless, we can consider that there is no evidence that using tap water to cleanse acute and chronic wounds in adults increases infection or healing, with some evidence that it reduces infection when compared to saline. There may be a trend towards a lower wound infection rate when povidone-iodine is used in surgical wounds, but this is not significant for varicose vein surgery.

However, despite the small number of studies by interventions (few cleansing solutions), the evidence is not strong enough to produce a best practice. On the other hand, these findings have extreme relevance for clinical practice, and they should be put into practice and considered by physicians, nurses and all health professionals who are interested in wound treatment. Prospective randomized controlled trials in this area need to be more robust in order to assist clinicians and policy makers in making informed decisions about the appropriate use of solutions for cleansing wounds.

Conclusion

The included studies provide results about the effectiveness of cleansing solutions for wound treatment in adults. The interventions included in this systematic review were tap water versus sterile saline and povidone-iodine-soaked gauze versus saline-soaked gauze. Data from two studies reporting the effectiveness of tap water versus sterile saline which compared wound infection rates were pooled in a meta-analysis.

All the studies included and the results of meta-analysis suggest that there is no evidence that using tap water to cleanse acute and chronic wounds in adults increases infection or healing with some evidence that it reduces infection when compared to saline. There may be a trend towards a lower wound infection rate when povidone-iodine is used in surgical wounds, but this is not significant for varicose vein surgery.

However, due to the small number of studies by interventions (few cleansing solutions), the evidence is not strong enough to produce a best practice.

Implications for practice

The interventions considered in this systematic review are effective and may be useful in practice to reduce the infection rate in adults with acute and chronic wounds and promote wound healing through cleansing.

Tap water was more effective than saline in reducing the infection rate in adults with acute and chronic wounds (Level of Evidence 1.a – Systematic Review of RCTs).

There is no evidence that using tap water to cleanse acute and chronic wounds in adults increases healing (Level of Evidence 1.c – RCT).

There may be a trend towards a lower wound infection rate when povidone-iodine is used in surgical wounds (Level of Evidence 1.d – Pseudo-RCT).

As the evidence is of high quality, health professionals may deliver the above interventions for wound treatment in adults (GRADE A).

Implications for research

To strengthen the current evidence base on the effectiveness of cleansing solutions for wound treatment, additional high quality RCTs (using CONSORT guidelines, for example) are required in order to update the sensitive subject meta-analysis.

In future researches, the needed sample size, power analysis and effect size have to be calculated to better address the study's methods, results and conclusions.

We recommend the use of a standardized and validated tool for the measurement of wound infection and healing, an assessor blinded to the intervention, the performance of RCTs or the use of other solutions for wound cleansing: Super-oxidized solution, 2% hydrogen peroxide, 2% chlorhexidine gluconate, polyhexanide (phmb) and betaine. We also recommend examining the effects on the wound itself and the effectiveness on various types of wounds, comparing between them, and measuring other outcomes such as patient comfort, pain and satisfaction.

Conflict of interest

There were no conflicts of interest.

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Appendix I: Search strategy

Academic Search Complete

Search Formula	Limiters	Results
(TI wound*) AND (AB infect* OR AB heal* OR AB clean*) AND (AB irrigat* OR AB bath* OR AB shower* OR AB water* OR AB "sodium chloride" OR AB detergent* OR AB povidone-iodine OR AB hydrotherapy OR AB chlorhexidine)	Published Date from: 19900101-20131231; Language: English, Portuguese, Spanish	335

CINAHL

Search Formula	Limiters	Results
(TI wound*) AND (AB infect* OR AB heal* OR AB clean*) AND (AB irrigat* OR AB bath* OR AB shower* OR AB water* OR AB "sodium chloride" OR AB detergent* OR AB povidone-iodine OR AB hydrotherapy OR AB chlorhexidine)	Published Date from: 19900101-20131231; Language: English, Portuguese, Spanish	534

MEDLINE

Search Formula	Limiters	Results
(TI wound*) AND (AB infect* OR AB heal* OR AB clean*) AND (AB irrigat* OR AB bath* OR AB shower* OR AB water* OR AB "sodium chloride" OR AB detergent* OR AB povidone-iodine OR AB hydrotherapy OR AB chlorhexidine)	Published Date from: 19900101-20131231; Language: English, Portuguese, Spanish	789

MedicLatina

Search Formula	Limiters	Results
(AB wound*) AND (AB infect* OR AB heal* OR AB clean*) AND (AB irrigat* OR AB bath* OR AB shower* OR AB water* OR AB "sodium chloride" OR AB detergent* OR AB povidone-iodine OR AB hydrotherapy OR AB chlorhexidine)	Published Date from: 19900101-20131231; Language: English, Portuguese, Spanish	6

Cochrane Central Register of Controlled Trials

Search Formula	Limiters	Results
AB (water OR "sodium chloride" OR pol?hexanide OR detergents OR	Published Date from: 19900101-20131231;	147

povidone-iodine OR chlorhexidine OR hydrotherapy OR shower OR bath OR irrigate) AND AB (infect* OR AB heal* OR AB clean*) AND AB wound*	Language: English, Portuguese, Spanish	

Cochrane database of systematic review

Search Formula	Limiters	Results
AB (water OR "sodium chloride" OR pol?hexanide OR detergents OR povidone-iodine OR chlorhexidine OR hydrotherapy OR shower OR bath OR irrigate) AND AB (infect* OR AB heal* OR AB clean*) AND AB wound*	Published Date from: 19900101-20131231; Language: English, Portuguese, Spanish	12

Nursing & Allied Health Collection: Comprehensive

Search Formula	Limiters	Results
AB (water OR "sodium chloride" OR pol?hexanide OR detergents OR povidone-iodine OR chlorhexidine OR hydrotherapy OR shower OR bath OR irrigate) AND AB (infect* OR AB heal* OR AB clean*) AND AB wound*	Published Date from: 19900101-20131231; Language: English, Portuguese, Spanish	63

Elsevier (via b-on)

Search Formula	Results
TI wound	0
TI ferida	0

Scopus

Search Formula	Results
(TITLE(wound*) AND TITLE-ABS-KEY(infect* OR heal* OR clean*) AND TITLE-ABS-KEY(irrigat* OR bath* OR shower* OR water* OR "sodium chloride" OR detergent* OR povidone-iodine OR hydrotherapy OR chlorhexidine OR polihexanide)) AND SUBJAREA(mult OR agri OR bioc OR immu OR neur OR phar OR mult OR medi OR nurs OR vete OR dent OR heal) AND PUBYEAR > 1989 AND (LIMIT-TO(LANGUAGE, "English") OR LIMIT-TO(LANGUAGE, "Spanish") OR LIMIT-TO(LANGUAGE, "Portuguese"))	1840

Scielo

Search Formula	Results
Words in the Abstract wound* AND (heal* OR infect* OR clean*) AND (chlorhexidine OR hydrotherapy OR povidone-iodine OR detergent* OR "sodium chloride" OR water* OR shower* OR bath* OR irrigat* OR polihexanide OR polyhexanide)	71

Lilacs

Search Formula	Limiters	Results
Words in the Title, Abstract, Subject (wound*) AND (heal* OR infect* OR clean*) AND (chlorhexidine OR hydrotherapy OR povidone-iodine OR detergent* OR "sodium chloride" OR water* OR shower* OR bath* OR irrigat* OR polihexanide OR polyhexanide)	Language: English, Portuguese, Spanish	136

JBI Library

Search Formula	Results
TI (wound*) AND AB (infect* OR AB heal* OR AB clean*)	4

ACP online

Search Formula	Results
with all of the words » “wound cleansing”	55

ACP Hospitalist

Search Formula	Results
with all of the words » “wound cleansing”	18

ACP Internist

Search Formula	Results
with all of the words » “wound cleansing”	10

Embase

	Search Formula	Results
#17	#1 AND #14 AND #15 AND ([english]/lim OR [portuguese]/lim OR [spanish]/lim) AND [embase]/lim AND [1990-2013]/py	843
#16	#1 AND #14 AND #15	1.083
#15	#5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13	522.637
#14	#2 OR #3 OR #4	2.277.586
#13	detergent*:ab AND [embase]/lim	28.044
#12	chlorhexidine:ab AND [embase]/lim	3.559
#11	hydrotherapy:ab AND [embase]/lim	530
#10	'povidone iodine':ab AND [embase]/lim	1.668
#9	'sodium chloride':ab AND [embase]/lim	10.797
#8	water*:ab AND [embase]/lim	442.302
#7	shower*:ab AND [embase]/lim	1.791
#6	bath*:ab AND [embase]/lim	36.026
#5	irrigat*:ab AND [embase]/lim	17.568
#4	clean*:ab AND [embase]/lim	48.312
#3	heal*:ab AND [embase]/lim	1.394.035
#2	infect*:ab AND [embase]/lim	980.441
#1	wound*:ti AND [embase]/lim	28.927

Health Techonology Assessment database

	Search Formula	Results
S11	S7 AND S10	2
S10	AB (water OR "sodium chloride" OR pol?hexanide OR detergents OR povidone-iodine OR chlorhexidine OR hydrotherapy OR shower OR bath OR irrigate)	21
S9	AB (water OR sodium chloride OR polihexanide OR detergents OR povidone-iodine OR chlorhexidine OR hydrotherapy OR shower OR bath OR irrigate)	21
S8	AB water OR sodium chloride OR polihexanide OR detergents OR povidone-iodine OR chlorhexidine OR hydrotherapy OR shower OR bath OR irrigate	21

S7	S5 AND S6	58
S6	AB wound*	70
S5	S2 OR S3 OR S4	1540
S4	AB heal*	1331
S3	AB clean*	15
S2	AB infect*	293
S1	TX wound*	199

'Grey Literature Report' from New York Academy of Medicine

Search Formula	Limiters	Results
Words in the Full text wound* AND (infect* OR heal* OR clean*)	Published Date from: 1990-2013	0

Mednar

Clinical trials

Search Formula	Results
Keyword: infect* OR heal* OR clean* / Title: wound* / Beginning Date Range: 1990-01-01 / Ending Date Range: 2013-12-31	100

National Library of Medicine

Search Formula	Results
Keyword: infect* OR heal* OR clean* / Title: wound* / Beginning Date Range: 1990-01-01 / Ending Date Range: 2013-12-31	0

National Institute of Nursing ResearchScirus.com website

Search Formula	Results
Keyword: infect* OR heal* OR clean* / Title: wound* / Beginning Date Range: 1990-01-01 / Ending Date Range: 2013-12-31	10

Scirus

BioMed Central

Search Formula	Limiters	Results
title:wound* AND All text: (infect* OR heal* OR clean*)	1990-2013	49

National Library of Australia Trove service

Health & Wellness Resource Center

Search Formula	Results
title:(wound*) subject: (infect* OR heal* OR clean*) date:[1990 TO 2013]	64

Health Collection

Search Formula	Results
title:(wound*) subject: (infect* OR heal* OR clean*) date:[1990 TO 2013]	151

ProQuest – Nursing and Allied Health Source Dissertations

Search Formula	Results
ti(wound*) AND ab (infect* OR heal* OR clean*) AND ab (bath* OR shower* OR water* OR "sodium chloride" OR detergent* OR povidone-iodine OR hydrotherapy OR chlorhexidine)	79

Banco de teses da CAPES (www.capes.gov.br)

Search Formula	Results
Subject = wound*; Start Year = 1990	0

RCAAP – Repositório Científico de Acesso Aberto de Portugal

Search Formula	Limiters	Results
Title (wound*) AND full text (heal* OR infect* OR clean*)	Language: English, Portuguese, Spanish	0

Appendix II: Appraisal instruments

MAStARI appraisal instrument

JBI Critical Appraisal Checklist for Randomised Control / Pseudo-randomised Trial

Reviewer _____ Date _____

Author _____ Year _____ Record Number _____

	Yes	No	Unclear	Not Applicable
1. Was the assignment to treatment groups truly random?	☐	☐	☐	☐
2. Were participants blinded to treatment allocation?	☐	☐	☐	☐
3. Was allocation to treatment groups concealed from the allocator?	☐	☐	☐	☐
4. Were the outcomes of people who withdrew described and included in the analysis?	☐	☐	☐	☐
5. Were those assessing outcomes blind to the treatment allocation?	☐	☐	☐	☐
6. Were the control and treatment groups comparable at entry?	☐	☐	☐	☐
7. Were groups treated identically other than for the named interventions	☐	☐	☐	☐
8. Were outcomes measured in the same way for all groups?	☐	☐	☐	☐
9. Were outcomes measured in a reliable way?	☐	☐	☐	☐
10. Was appropriate statistical analysis used?	☐	☐	☐	☐
	☐	☐	☐	☐

Overall appraisal: Include ☐ Exclude ☐ Seek further info. ☐

Comments (Including reason for exclusion)

Appendix III: Data extraction instruments

MAStARI data extraction instrument

JBI Data Extraction Form for Experimental / Observational Studies

Reviewer _____ Date _____

Author _____ Year _____

Journal _____ Record Number _____

Study Method

RCT ☐ Quasi-RCT ☐ Longitudinal ☐

Retrospective ☐ Observational ☐ Other ☐

Participants

Setting

Population

Sample size

Group A _____ Group B _____

Interventions

Intervention A

Intervention B

Authors Conclusions:

Reviewers Conclusions:

Study results

Dichotomous data

Outcome	Intervention ( ) number / total number	Intervention ( ) number / total number

Continuous data

Outcome	Intervention ( ) number / total number	Intervention ( ) number / total number

Appendix IV: Included studies

MAStARI

<table>
<tr><th>Study</th><th>Methods</th><th>Participants</th><th>Intervention A</th><th>Intervention B</th><th>Notes</th></tr>
<tr><td rowspan="2">[8], Moscati RM, Mayrose J, Reardon RF, Janicke DM, Jehle DV, 2007</td><td rowspan="2">RCT</td><td rowspan="2">People older than 17 years and with uncomplicated acute skin lacerations requiring staple or suture repair</td><td>Wound irrigation with sterile saline was undertaken by the provider. Wounds were irrigated with a 35 ml syringe using a splash guard.</td><td>Wound irrigation with tap water was undertaken by the provider. Wounds were irrigated for a minimum of 2 minutes.</td><td rowspan="2">Compared with sterile saline, tap water for wound irrigation is more cost-effective and appears to be equally safe and efficacious. Despite these results, there are same limitations. The process of randomization is unclear, as well as whether those assessing outcomes were blind to the treatment allocation. The participants were not blind to treatment allocation and the outcomes of people who withdrew were not described and included in the analysis.</td></tr>
<tr><td colspan="2">Standard protocol in both interventions

After irrigation, all wound care including closure was in the standard fashion at the discretion of the treating clinician. No prophylactic antibiotics were given. Use of any skin preparations (e.g. povidine-iodine) on the area surrounding the wound, but not inside the wound, was at the discretion of the treating clinician.</td></tr>
<tr><td rowspan="2">[17], Griffiths RD, Fernandez RS, Ussia CA, 2001</td><td rowspan="2">RCT</td><td rowspan="2">Patients with acute or chronic non-sutured wounds (grade II or III according to Carville’s definition)</td><td>Wound irrigation with sterile normal saline using a 30ml syringe and 20G cannula for a six-week period. Both solutions were delivered at room temperature.</td><td>Wound irrigation with tap water using a 30ml syringe and 20G cannula. Both solutions were delivered at room temperature.</td><td rowspan="2">There was no statistically significant difference between the healing and infection rates in the wounds from both groups. The authors concluded that the results support the use of tap water as a wound cleansing agent. The authors believe it will save nursing time, reduce costs and increase patients’ participation in their care.</td></tr>
<tr><td colspan="2">Standard protocol in both interventions

To maintain uniformity, a standard protocol was followed after the existing dressing was removed. Excess exudate was wiped with gauze, and the wound was irrigated with the solution from the bottle marked with the participant’s</td></tr>
</table>

			name. A 30ml syringe and 20G cannula were used. If the patient had more than one wound, all wounds were cleansed with the allocated solution.		However, the process of randomization is unclear, as well as whether control and treatment groups were comparable at baseline.
[27], Walker SR, Smith A, 2013	RCT	Patients undergoing primary saphenofemoral ligation for varicose veins associated with skin changes	Saline-soaked gauze placed in the groin wound.	Betadine-soaked gauze placed in the groin wound.	There was more than 50% reduction in the risk of a groin wound infection when a povidone-iodine-soaked gauze was placed in the groin wound compared to that with a saline-soaked Gauze. The process of randomization is not clear. It is unclear if the participants were blind to treatment allocation and if the allocation to treatment groups was concealed from the allocator. The outcomes of people who withdrew were not described and included in the analysis.
			Standard protocol in both interventions All patients had a preoperative venous duplex scan to plan surgery. All patients were planned for day case surgery. Upon admission, they received the usual preoperative work up, including record of their weight and height. Their past medical history was recorded. All patients received a preoperative dose of low-molecular-weight heparin (Clexane 20 mg; SanofiAventis, Macquarie Park, Australia) as thromboembolic prophylaxis. No hair removal was used pre- or intraoperatively. All procedures were performed under standard general anesthetic. The groin area and legs were prepared for surgery aseptically using aqueous betadine. No prophylactic antibiotics were used in this study. The surgical procedure in the groin was performed in a standard manner to expose the saphenofemoral junction through a transverse incision by a consultant vascular surgeon or a surgical registrar under direct supervision of the consultant surgeon. The saphenofemoral junction was divided and ligated with an absorbable braided transfixion suture (Vicryl; Ethicon, North Ryde, Australia). All tributaries to the junction were divided and ligated with the same suture material. In all cases, the great saphenous vein was then pin-stripped to the level of the knee.		

Appendix V: List of excluded studies by assessment of methodological quality

MAStARI

Anglen JO. Comparison of soap and antibiotic solutions for irrigation of lower-limb open fracture wounds A prospective, randomized study. The Journal of Bone & Joint Surgery. 2005;87(7):1415-22.

> **Reason for exclusion: The study received a "yes" answer to four questions in the standardized critical appraisal instrument from the JBI-MAStARI. Thus, we considered it to be a study of poor quality.**

Hadi SF, Khaliq T, Bilal N, Sikandar I, Saaiq M, Zubair M, et al. Treating infected diabetic wounds with superoxidized water as anti-septic agent: a preliminary experience. J Coll Physicians Surg Pak. 2007;17:740-3.

> **Reason for exclusion: The study received a "yes" answer to two questions in the standardized critical appraisal instrument from the JBI-MAStARI. Thus, we considered it to be a study of poor quality.**

Mohammadi AA, Seyed Jafari SM, Kiasat M, Pakyari MR, Ahrari I. Efficacy of debridement and wound cleansing with 2% hydrogen peroxide on graft take in the chronic-colonized burn wounds; a randomized controlled clinical trial. Burns. 2013;39(6):1131-6.

> **Reason for exclusion: The study received a "yes" answer to three questions in the standardized critical appraisal instrument from the JBI-MAStARI. Thus, we considered it to be a study of poor quality.**

Luca Dalla Paola M, Brocco E, Senesi A, Merico M, Daniele De Vido M, Assaloni R, et al. Super-Oxidized Solution (SOS) Therapy for Infected Diabetic Foot Ulcers. Wounds. 2006;18(9):262-270.

> **Reason for exclusion: The study received a "yes" answer to one question in the standardized critical appraisal instrument from the JBI-MAStARI. Thus, we considered it to be a study of poor quality.**

Godinez FS, Grant-Levy TR, McGuirk TD, Letterle S, Eich M, O'Malley GF. Comparison of normal saline vs tap water for irrigation of minor lacerations in the emergency department. Academic Emergency Medicine 2002;19(5):396–7.

> **Reason for exclusion: The study received a "no" answer to two questions and a "unclear" answer to eight questions in the standardized critical appraisal instrument from the JBI-MAStARI. Thus, we considered it to be a study of poor quality.**