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Effectiveness of Alcohol-Based Hand Rubs in Glove Hygiene: A Meta-Analysis and Systematic Review

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Abstract

Introduction: *Hand hygiene is crucial for preventing hospital-acquired infections, though gloves have been reported to curb the spread of infection, but they have their limitation. While recommended for specific procedures, they don't guarantee complete protection and frequent changes are resource limiting. This study investigates the potential of alcohol-based hand rubs (ABHR) for disinfecting gloves worn by healthcare workers (HCWs).* ***Methodology:*** *We conducted a meta-analysis searching six databases for studies on ABHR use for glove hygiene. Twelve studies met the criteria, evaluating the efficacy of ABHR on microbial reduction on gloves and the impact on infection rates.* ***Results:*** *The analysis showed significant reductions in microbial counts on gloves after ABHR application, regardless of glove type. Ten studies evaluated colony forming unit count before and after disinfection. The standard mean difference with 95% CI between the pre and post CFU count was –3.53 [–6.04, –1.02]. The test of overall effect showed significant difference in the microbial count on gloves before and after disinfectant (Z = 2.76; P = 0.006). Two studies examining infection rates reported a decline in rates of hospital acquired infections after implementing glove disinfection.* ***Conclusions:*** *This study highlights the urgent need of detailed studies to explore cost-effectiveness, user acceptance, and long-term effects of ABHR on various glove materials. As in-depth studies would help to furnish guidelines on glove hygiene, which will directly affect the patient care and infection rates in hospitals.*

Keywords: Alcohol, glove hygiene, disinfection, infection control practices, hand rubs

INTRODUCTION

Hands play an important role in transferring microbes including beneficial microbes and pathogens. Hands of healthcare worker (HCW) are contaminated with pathogens and cross transmitted among patients and environment. It is known that hands of health care workers are the most important means of hospital acquired infections. The risk of infection can be minimised by thorough hand washing and use of gloves. Wearing of gloves during patient care is recommended as studies on bare hand showed that all potential pathogens may not be removed by hand washing if hands are heavily contaminated. Some prospective control trial provide evidence on decrease in transmission due to wearing of gloves. However, gloves do not provide complete protection, there is evidence on presence of bacteria on gloves of an HCW during patient care [1, 2]. Moreover, the perforation in overuse of single glove may also transmit pathogen to hands of HCW [3–5].

Gloves must be worn as single use and should be changed between different patients/treatment

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activities [6–8]. However, the proper usage of gloves under WHO guidelines has rarely been reported. Previous observational studies provide evidence that the HCW does not change gloves after every patient and are sometimes overused [9–11]. Inappropriate use of gloves leads to increase risk of cross transmission. Gloves offer protection against contamination if used properly with international recommendations. However, implementation of actual hand hygiene practices during multiple activities on same patients to doff gloves, perform hand disinfection and don a new pair of gloves is probably unrealistic [12, 13]. Therefore, decontamination of gloves would be beneficial alternative. Best and Kennedy 1992 recommended decontamination of gloved hands under limited circumstances [14, 15]. However, neither national nor international guidelines recommend disinfection of gloves during patient care [16, 17]. Moreover, none of the manufacturing company also recommends the disinfection of gloves. In 2016, the hospital for Commission for hospital hygiene and Infection Prevention at the Robert Koch Institute, Berlin Germany proposed that when the workflow can only be assured without a glove change, glove may be used for multiple activities on the same patient with a disinfection of gloved hands [18]. Disinfecting gloved hands has substantial advantage such as reducing the workload of healthcare workers, protecting the environment and reducing cost. During COVID pandemic due to resource shortage it was recommended to perform glove hygiene before and after patient contact [19, 20]. The hand hygiene report of 2020 has listed alcohol-based hand rub and glove use as research priority. There is limited evidence on disinfection of gloves, rather no guidelines are available till date on glove disinfection. Glove disinfection depends on type of disinfection used, material of glove and time period for which disinfection is applied. Till date there is very scarce data on evidence of glove disinfection with alcohol. Besides none of the studies have a uniform protocol for evaluating this objective. Therefore, this meta-analysis evaluates the clinical evidence that investigates the use of alcohol-based hand rubs in hospitals as an alternative method for ensuring glove hygiene.

Main Text

Objective: Efficacy of alcohol to reduce the microbial load on gloves.

METHODOLOGY

Ethics Permission and Dissemination: This metanalyses does not require ethical approval.

Inclusion and Exclusion Criteria

Studies were included if they met the following criteria: colonization being reported as an outcome, the intervention being studied includes gloves used during patient care, the study was either randomized controlled trial, non-randomized quasi experimental study or observational study. Studies were excluded if the investigator considered only hand hygiene compliances. The articles including expert opinion, literature reviews or including no details were excluded. Studies published in only abstract form will always be excluded. But their reference will be traced.

Type of Intervention

- Contamination of gloves/gloved hands of HCWs or healthy volunteers with microorganisms followed by a disinfection with alcohol.
- Application of alcohol-based solutions on gloved hands.
- Effect on rates of infection after and before using alcohol as disinfection

Type of Outcomes

- The outcome measure in this study was the log reduction of microorganisms or change in colony count on gloved hands after using alcohol.
- We also evaluated for change in rates of infection after and before implementation of glove disinfection.

Search Strategy

The search strategy was designed to identify both published and unpublished studies and was divided into following stages.

- Partial search Medline to identify the keywords contained in the title, abstract and subject descriptors.
- The synonym and terms identified from above scenario was used for extensive search of the literature.
- Relevant bibliography and references in the articles found in above scenario were also searched.

To obtain the full article various attempts were made such as search in National medical library, B.B Dixit Library, Sci hub and Authors were also attempted.

Initial Keywords or Terms

Alcohol based glove hygiene, alcohol as a disinfectant on glove, alcohol disinfectant, glove hygiene, disinfection of gloves

Information Sources

Due to limited availability of data, the time limitation was not applied. The systematic search was performed based on above keywords. The database searched were PubMed, Medline, Cockrane central register clinical trial, Embase, Web of Science Core collection, Google Scholar. The search was performed on 20 June 2024 and all the relevant studies till the date were included.

Critical Appraisal

Two reviewers (MP, VS) independently reviewed the studies and critically appraised each study. The discrepancies in the results were resolved after a discussion among them. The quality assessment of studies was done based on checklist used for quasi experimental studies [22].

Data Extraction

All the included studies were evaluated manually and data was extracted. All the data was exported into a Microsoft excel. The extracted data included author(s) name, date of publication, year, study design, sample size, type of solution used, types of gloves used, amount and time period for applied disinfectant. The studies on glove disinfection does not have uniformity. As data in the articles was presented as log reduction, some of the reported absolute number and some in median (SD). To maintain the uniformity the data is converted [23] and presented in standard deviation (SD).

Data Analysis

A narrative synthesis of extracted information on determinants of glove hygiene and metan-analyses for the glove hygiene was carried out. The quasi-experimental studies are mentioned in narrative form. Where possible study results were pooled for meta-analysis using Review Manager software from the Cochrane collaboration (Review Manager 5.4.1). Data pooling was based on comparable intervention and outcome measurement. Double data entry was crosschecked to minimise risk of error. For studies on microbial count continuous variation analysis was used and standard mean difference was reported with 95% confidence interval, while studies assessing effect of glove disinfection with alcohol on the rate of hospital infection were analysed using dichotomous variation and reported as risk ratio. The infection rate was reported as per 1000 patient days.

The two outcomes were assessed in this metanalysis i.e the reduction in microbial load on gloves after disinfection and the effect on hospital infection after using ABHR as a disinfectant for glove hygiene. The first outcome was further analysed in two different categories, primarily without considering glove type and considering only studies on latex gloves. The data was log converted for uniformity.

RESULTS

Study Selection

The search from six different database yielded 98,589 studies. After considering duplicates and, initial title/abstract 261 studies were further evaluated for eligibility criteria, study design, specific to

topic and adequate information. After screening 17 studies were assessed for eligibility. Among all 13 meet all the inclusion criteria's and complete manuscript was found. Of these 13 studies one study [25] presented results in a different manner such that the no. of colonies on gloves was not reported despite only no. of sterile and infected gloves after intervention were reported. Hence it was included as narrative form. Figure 1 depicts the PRISMA flow diagram for studies included for metanalysis.

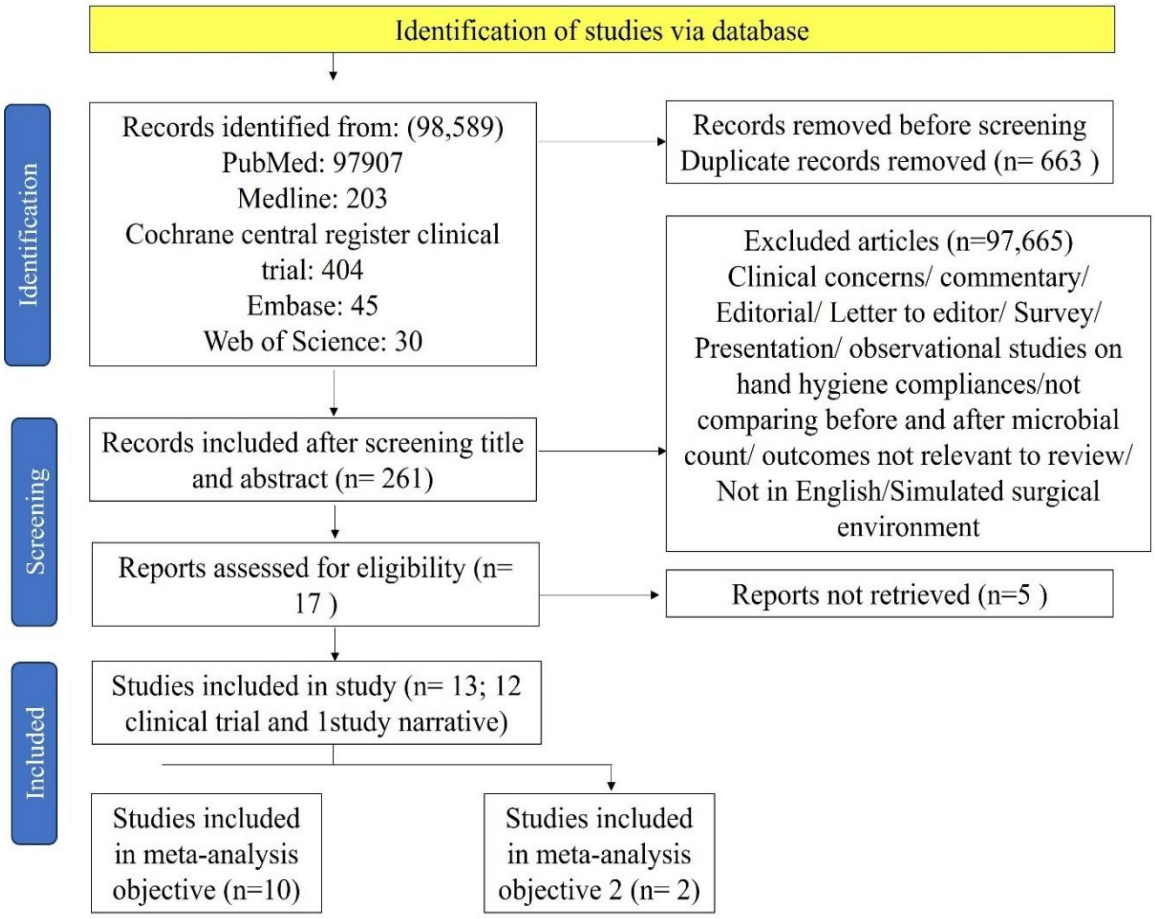

Figure 1. Prisma flow diagram for selection of studies for metanalysis only on efficacy of alcohol to decontamination the gloves.

Study Characteristics

Details of the 13 studies included are mentioned in Table 1. The timeframe of the included study was 1988-2023. Seven studies were performed in developing countries and six from developed countries. These studies are based on two different objectives.

- Decontamination of gloves using alcohol-based disinfectants: 10 studies.
- What is the effect on rates of infection after introducing alcohol-based glove hygiene in hospitals: 2 studies.

Off all the studies included 7 studies conducted research on gloves don by healthy volunteers and 3 studies were conducted on health care workers. A study was designed specifically on gloves handling central venous line insertion [26]. The research conducted on healthy volunteers applied a specific concentration of inoculum on gloves. Assadian et al applied *Staphylococcus epidermis* on gloves [27], Scheithauer et al used *Escherichia coli*, and two studies used *Escherichia coli* and *Pseudomonas aeruginosa* [28–30]. An older study by Doebbeling applied inoculum containing *Staphylococcus aureus, Pseudomonas aeruginosa, Serratia marcescens* and *Candida albicans* [31]. The study by *Monistrol et al.* was conducted in medical ward [32], while a study was conducted in surgical ward, medical ward, intensive care unit, intermediated care unit [27].

Table 1. Characteristics of included studies.

Author	Year	Type of gloves	No. of test	Type of solution	Type of hand rub	Time of application	Any specific organism if used to infect gloves
Assadian [20]	2018	Powder free sterile latex gloves	10	Solution	Isopropanol 60% v/v	NM	*S. epidermidis*
Scheithauer S [21–24]	2016	Vasco Braun/Nitrile Blue Eco Plus/ Latex Med Comfort	20	Solution	2 Proponal/Sensiva/ Descoderm/ Descoderm pure/Promanum	30s	*E. coli*
Thom KA [22]	2023	Non sterile gloves	662	Solution	Alcohol	14s	*E. coli* or *P. aerginosa*
S. Mehtar [23]	1991	Biogel, Regent Dispo Surgical gloves and Ansell gammex	6	Solution	70% methyl alcohol	30s	*E. coli* and *P. aeruginosa*
Doebbeling BN [24]	1988	Latex gloves	20	Solutiuon	60% isopropyl alcohol	10s	*S. aureus*, *P. aeruginosa*, *Serratia marcescens, Candida auris*

Blinding

It is not possible to blind the study in such a small number. In an attempt to reduce bias, the outcome assessor (alcohol use) should be blinded to the allocation. However, only study by Lee et al. [33] conducted double blinded study and the study by Thom et al. and Paulson et al, [29, 34] was randomized trial. All other studies were prospective intervention study.

Attributes of Intervention

All the studies used alcohol solution except Tomas et al. [35] who also documented wipes, while for the analysis purpose data from only solution was comprehend for metanalysis. All the studies varied in types of gloves used, 4 used latex gloves, 3 studies did not mention the type of gloves used, one reported sterile surgical glove. A used combination of types of gloves and disinfectant [26]. This study evaluated Nitrile Blue Eco-plus, Vasco Braun and Latex Med Comfort and reported Nitrile Blue to perform the best among others. Additionally, one more study [28] used three different types of gloves Biogel, Regent Dispo Surgical gloves and Ansell gammex. Five studies used ≤70% alcohol as disinfectant while only one study used 83% ethanol as disinfectant and three studies did not report the percentage of alcohol/chlorohexidine.

Three studies separately analysed disinfectant efficacy of different types of alcohol. *Scheithauer et al.* conducted experiments on 2 Proponal, Sensiva, Descoderm, Descoderm pure, Promanum and *Maristol et al.* on 2-propanol, 1-propanol, mercetronium ethylsulfate and other study compared disinfectant efficacy among non-antimicrobial lotion soap, antimicrobial lotion soap, alcohol gel sanitizer, combination of soap and alcohol [34].

The time period of application varied from 10 seconds to 30 seconds. Four studies applied for 30 seconds. Except one study all the study reported colony count before and after single patient contact. A research study demonstrated the no. of organism on gloved hands after 5 patient contact [28].

Risk of Biasness

To assess the quality of non-randomized study, a modified checklist was developed based on questionnaire [22]. This checklist includes 20 questions and scoring of studies was done by o and 1. Figure 2 shows the details of questions on which risk of biasness was evaluated. The highest score was 14 for two studies, the score of other studies were in range of 8–12.

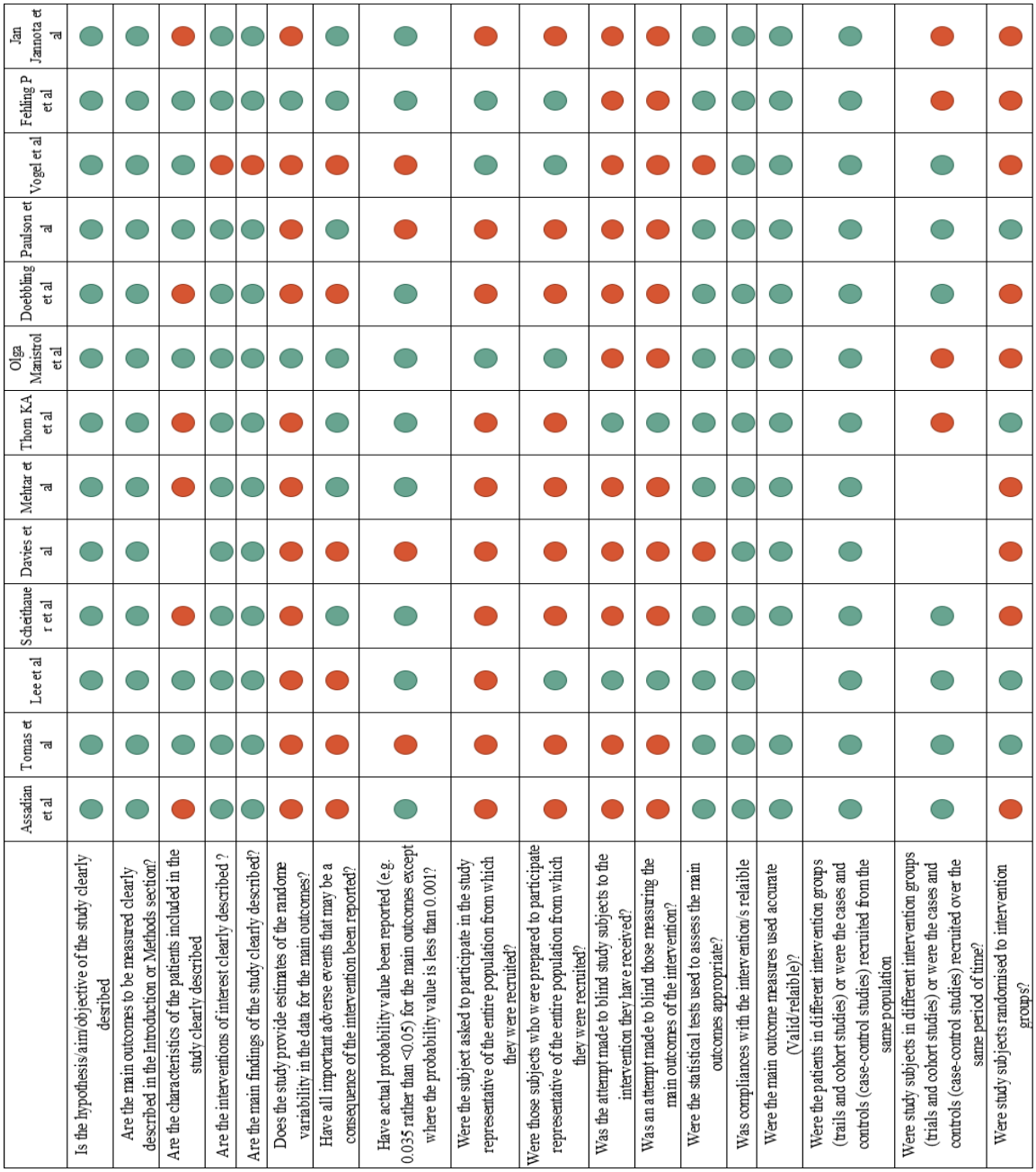

Figure 2. Questionnaire used to assess the quality of selected studied.

Interpretations

The included studies were analysed in a stratified way. In the first stratification we did not consider the different gloves type evaluated in a single study, such as Scheithauer et al., evaluated disinfection in three different types of gloves, therefore for first stratification it was considered as one glove and an average mean value was calculated for them. Further for second stratification all the glove types in included study were considered, such that mean value of three different gloves were included. The third stratification includes studies on efficacy of disinfection to reduce the hospital infection.

Effect of Alcohol on Glove Disinfection Considering Only Glove Types

Ten studies evaluated colony forming unit count before and after disinfection. The total sample size before was 1039 and 1069 after disinfection. The highest weight of study was Thome et with size 662 in each group. Figure 3 shows represent the forest plot of all included studies and their details as evidenced by Revman software. The standard mean difference with 95% CI between the pre and post

CFU count was –3.53 [–6.04, –1.02]. The test of overall effect showed significant difference in the microbial count on gloves before and after disinfectant (Z = 2.76; P = 0.006).

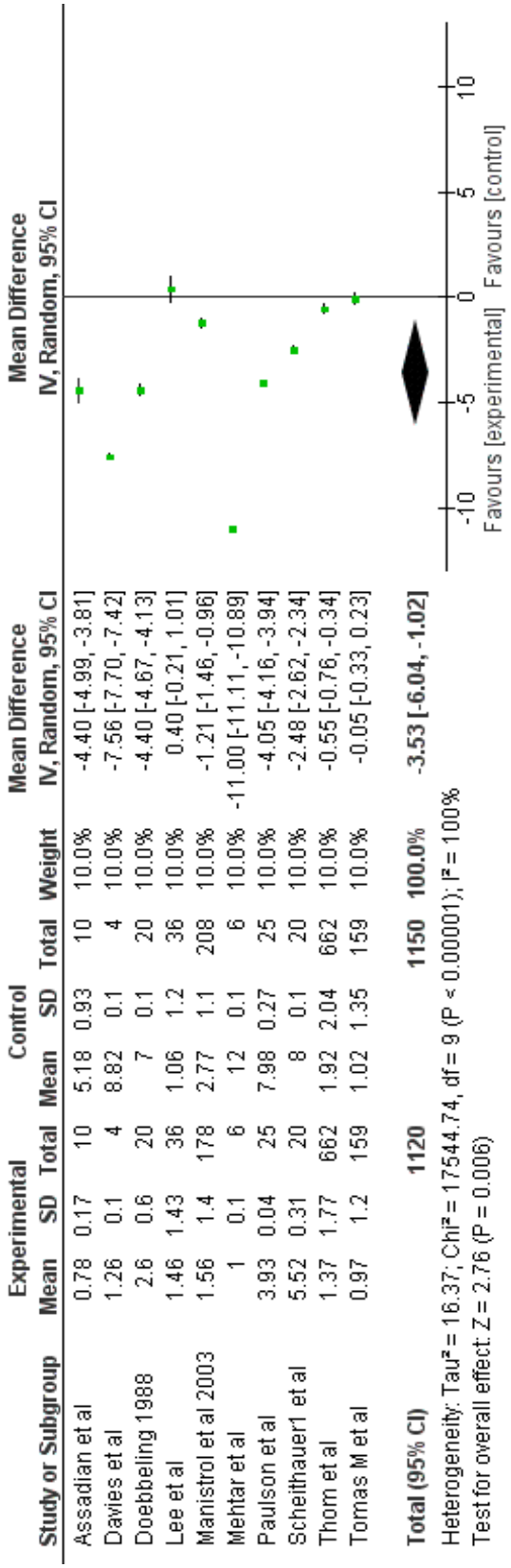

Figure 3. Forest plot of overall pooled effect of glove disinfection by alcohol.

Effect of Alcohol on Glove Disinfection Considering Glove Types

Due to ease in availability and economic Latex are most commonly used gloves in India [36]. Of all four studies consider use of latex glove in their experiment which were included for analysis. The total sample size before and after disinfection was 179. The highest weight of study was *Thome et al.*, Figure 4 shows represent the forest plot of all included studies and their details as evidenced by Revman software. The standardized mean difference in CFU counts between pre- and post-disinfection was –5.93 (95% CI: –8.55 to –3.23). The test of overall effect demonstrated a statistically significant reduction in microbial load on gloves following disinfection ($Z = 4.45$, $P < 0.001$).

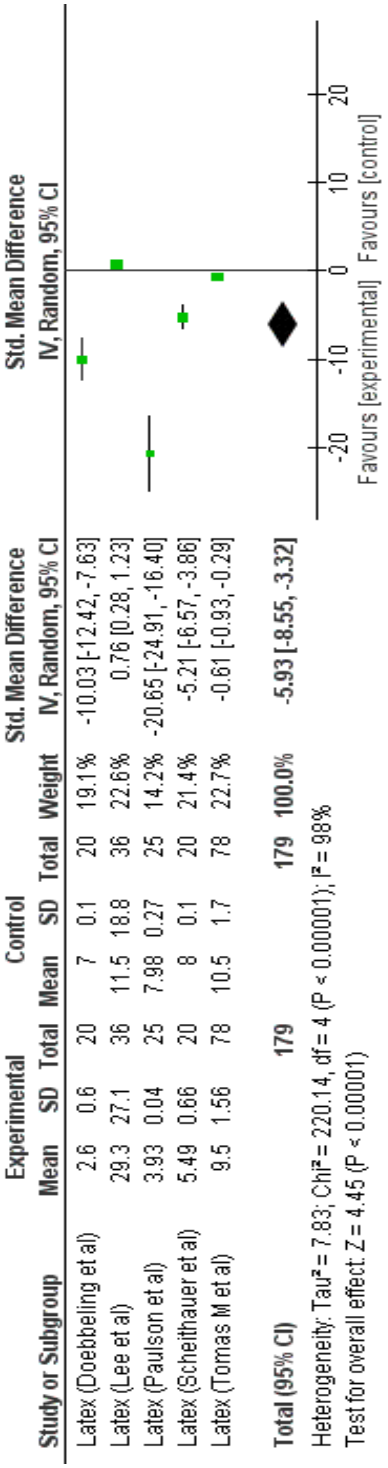

Figure 4. Forest plot of latex glove disinfection.

Effect of Glove Disinfection by Alcohol on Hospital Infection

Only two studies evaluated the infection rates before and at intervention. A study by Janota et al. [37] asses the rate of late onset sepsis in preterm birth childrens. The rate of infection significantly decreased when alcohol was used as gloves disinfection as an intervention during patient care. Fehling et al. [38] performed study in stem cell transplant patients and reported significant decrease in severe infection during phase 2 where gloved hand disinfection was allowed. To normalize the data the infection rate was considered as per 1000 patient days. The test of heterogeneity showed significant variability among studies I^2 91%. Test of overall effect showed significant difference ($Z = 5.19$; $P < 0.001$, Figure 5) in the rate of infection before intervention and after introducing intervention.

Figure 5. Forest plot of effect of disinfection on hospital infection rates.

Effect on Permeability

Limited studies also evaluated the durability of the gloves. *Mehtar et al.* [30] found that among three tested gloves Regent surgical' gloves and 'Biogel' were found to be the most resilient and capable of withstanding manual activity and Ansell gloves were the least capable of doing so. *Scheithauer* [28] also provide evidence for the tightness and perforation of gloves. In the check for tightness, only the Vasco Braun® gloves showed no leaks in all samples tested, followed by the Ampri Nitril Blue Eco plus® gloves with one leak, and the Latex Med Comfort® gloves with a total of seven leaks.

DISCUSSION

This study aimed in determining the efficacy of disinfection to reduce the microbial load on gloves used in patient care. This metanalysis showed that the use of disinfectant significantly reduces the count of microorganisms on gloves. To the best of authors knowledge this is the first metanalysis on reduction of pathogens on gloves. Most of studies have found that disinfection of gloved hand with alcohol is safe and effective and have significantly reduces the colony counts on gloves [15, 38]. Though the study by Lee et al. [33], who reported that the residual micro-organism count was higher in single and double gloved hands as compared to bare hands. Contrary to these other studies reported significantly low cfu count in gloved hands as compared to bare hands. Moreover, a report on blood stream infections and NEC in a retrospective study showed a strong negative association on glove use and late onset BSIs. They observed that glove use followed by 70% alcohol rub to the gloved hands prior to patient contact decreased rates of late-onset sepsis by 20% compared with hand hygiene alone [39].

Given the substantial variations among studies this metanalyses is essential to consolidate findings and enhance our understanding. Similar to other small studies [40] we found that application of alcohol on gloves significantly reduce the microbial count ($Chi^2 = 222.81$, df = 8 ($P< 0.001$)). Considering the studies on only latex gloves also found reduction in microbial count with the application of disinfection ($Chi^2 = 448.9$, df = 12 ($P< 0.001$)). Till date, there are only two studies on effect of glove disinfection on nosocomial infection and both the studies showed reduction in hospital infection rate after implementing the intervention of alcohol disinfection. Most of the studies lack considering the outcome for perforation, stickiness of glove material and integrity of gloves after several use of alcohol. Different studies have evaluated different types of gloves for integrity after several use. We highly recommend considering conducting all gloves type in single study with different disinfectant. Additionally, it would be useful if the government possess an implication on manufacturers of glove and disinfectant to conduct trials in order to collect more data [41, 42].

The limitation of this study is certain methodological concern in included studies. All the studies follow different methodology. There was clear lack of uniformity among studies having same outcome. Few studies did not provide log reduction of cfu therefor the decreased cfu count was log converted. Some did not take samples from healthcare workers rather they infected the gloves with known amount of organism and then applied disinfectant for outcome. An ideal study would have been to compare an exposed group to one with non-exposed group. There is a high need of studies with adequate power to detect the effect of treatment, statistical formula should be should be used to calculate the sample size. Comparative studies should be conducted on different disinfectant to evaluate the most suitable combination of glove and disinfectant type with time and quantity of disinfection. Despite presence of high level of heterogeneity, we evaluated the data on the effect of disinfectant to reduce the microbial count on gloves, as this may prompt further research and contribute valuable insights. This valuable data would have the potential to reduce the nosocomial infections, which is a major global problem in LMIC's in cost effective manner.

CONCLUSION

This metanalysis promotes to conduct an ideal well designed study to compare an exposed group with non-exposed group. There is a high need of studies with adequate power to detect the effect of treatment, statistical formula should be should be used to calculate the sample size. Comparative studies should be conducted on different disinfectant to evaluate the most suitable combination of glove and disinfectant type with time and quantity of disinfection.

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