

Effectiveness of Hydrogen Peroxide in Decontaminating Medical Devices against Health-care Associated Infections (HAIs)

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Abstract. Morbidity and mortality rates for patients who die in hospitals are increasing due to healthcare-associated infections (HAIs). Therefore, scientific studies are needed to determine the effectiveness of hydrogen peroxide decontamination on HAIs levels. T Scopus, PubMed, CINAHL, and SAGE databases were used for research searches. This study used the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines. Keywords entered for the search were decontamination OR hydrogen peroxide AND prevention AND Infection AND HAIs. The search included articles published between 2013 and 2023 in original research. We found 10 articles discussing decontamination interventions with hydrogen peroxide to prevent HAIs, using randomized control trials or quasi-experimental designs. Hydrogen peroxide has been proven to be effective against microorganisms such as bacteria, viruses, fungi, spores and parasites. Hydrogen peroxide has strong oxidizing properties that decomposes into oxygen and water making it environmentally friendly. Hydrogen peroxide produces hydroxyl and hydroperoxyl radicals which attack cell walls and destroy cells, causing collapse. Hydrogen peroxide has been proven to be effective in killing microorganisms thereby preventing the occurrence of HAIs. The application of hydrogen peroxide in decontamination is safe for the environment, patients, staff and medical equipment.

Keywords: Decontamination, HAIs, Hydrogen Peroxide, Infection, Prevention

1 Introduction

Nosocomial infections or health-care-associated infections (HAIs) are a health problem in many countries, including Indonesia [1]. Healthcare-associated infections (HAIs) continue to be a major problem in the morbidity and mortality of hospital patients worldwide. [2]. Healthcare-associated infections (HAIs) result in death in patients and the risk of environmental pollution [3]. Decontamination of medical devices has been carried out to prevent the incidence of HAIs through various methods [4]. One of them is hydrogen peroxide, but the incidence of HAIs in hospitals is still quite high. Therefore, this study aims to conduct a literature review regarding the effectiveness of hydrogen peroxide against HAIs in hospital patients.

Research [3] indicates that HAIs afflict one in every 31 Americans and cause about 72,000 fatalities annually. The World Health Organization (WHO) reports that in 2016, the incidence rate of HAIs was 19.1%. Due to infections with nosocomial and multi-resistant organisms (MRO), 4.5 million patients in Europe and 1.7 million patients in the US suffered from healthcare-associated infections (HAIs) [5]. Data from 50 nations gathered by the Centers for Disease Control and Prevention (CDC) also reveal a high frequency of healthcare-associated infections (HAIs) in a number of rooms, including the intensive care unit (ICU) (41%), the neonatal intensive care unit (NICU) (8%), and the nursing room (45%). According to data from the Ministry of Health in 2017, Indonesia continues to have a high rate of HAIs, or nosocomial infections, ranging from 6–16% on average [6].

HAIs occur due to drug-resistant microorganisms carried by infected patients or colonized into the environment so that they survive for a long time and are transferred through contact with other patients or through the hands of health workers [7]. Interventions to stop the spread of multi-resistant organisms (MRO) include the use of alcohol for disinfection and decontamination, the addition of hydrogen peroxide during the sterilizing process, the creation of design guidelines, training and education initiatives, and the creation of standard operating procedures. [4]. Disinfection and decontamination are often added with hydrogen peroxide because it has strong oxidizing properties [8]. In addition, hydrogen peroxide can reduce contamination in air, water, and solid surfaces. This can improve patient safety and reduce healthcare costs [9].

Numerous consequences that healthcare-associated infections (HAIs) have for patients, both directly and indirectly, have prompted the development of numerous initiatives aimed at preventing transmission. One of the main goals of patient safety infection issues in hospitals is the prevention of healthcare-associated infections (HAIs). Numerous investigations have been carried out about the prevention of healthcare-associated infections (HAIs); however, there are no studies that concentrate on the efficacy of hydrogen peroxide in the literature. As a result, this research is helpful in determining how successful hydrogen peroxide decontamination is in reducing hospital patient HAI levels. Consequently, medical equipment decontamination can be optimized to lower healthcare-associated infections (HAIs).

2 Research Methods

The 2020 Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) standards were followed in the performance of this systematic review investigation. For the sake of study searches in the online library databases Scopus, PubMed, CINAHL, and SAGE, a list of keyword combinations was prepared. Decontamination OR hydrogen peroxide AND prevention AND infection AND HAIs were the search terms entered. Articles written

exclusively in English and focusing on preventing associated diseases that were published between 2013 and 2023 were included in the search. The current systematic review did not include any case studies, novels, policy summaries, theses or dissertations, or non-peer reviewed articles.

Prior to first screening, duplicates were eliminated and studies found through searches in the online library databases Scopus, PubMed, CINAHL, and SAGE were added to the Mendeley Desktop library. Papers that did not report preventive treatments were omitted in the second phase, which involved screening all papers based on title reading. In the third phase, after reading the abstract and discovering that the trial did not report preventive treatments, records were deleted. In the fourth step, all non-peer-reviewed publications, reports, case studies, theses/dissertations, books, and policy summaries were excluded from the systematic review, and only peer-reviewed articles published in journals were included. A full-text review was also conducted. A synopsis of the chosen research is documented in the fifth stage. The detailed process for selecting articles for analysis is shown in **Figure 1**.

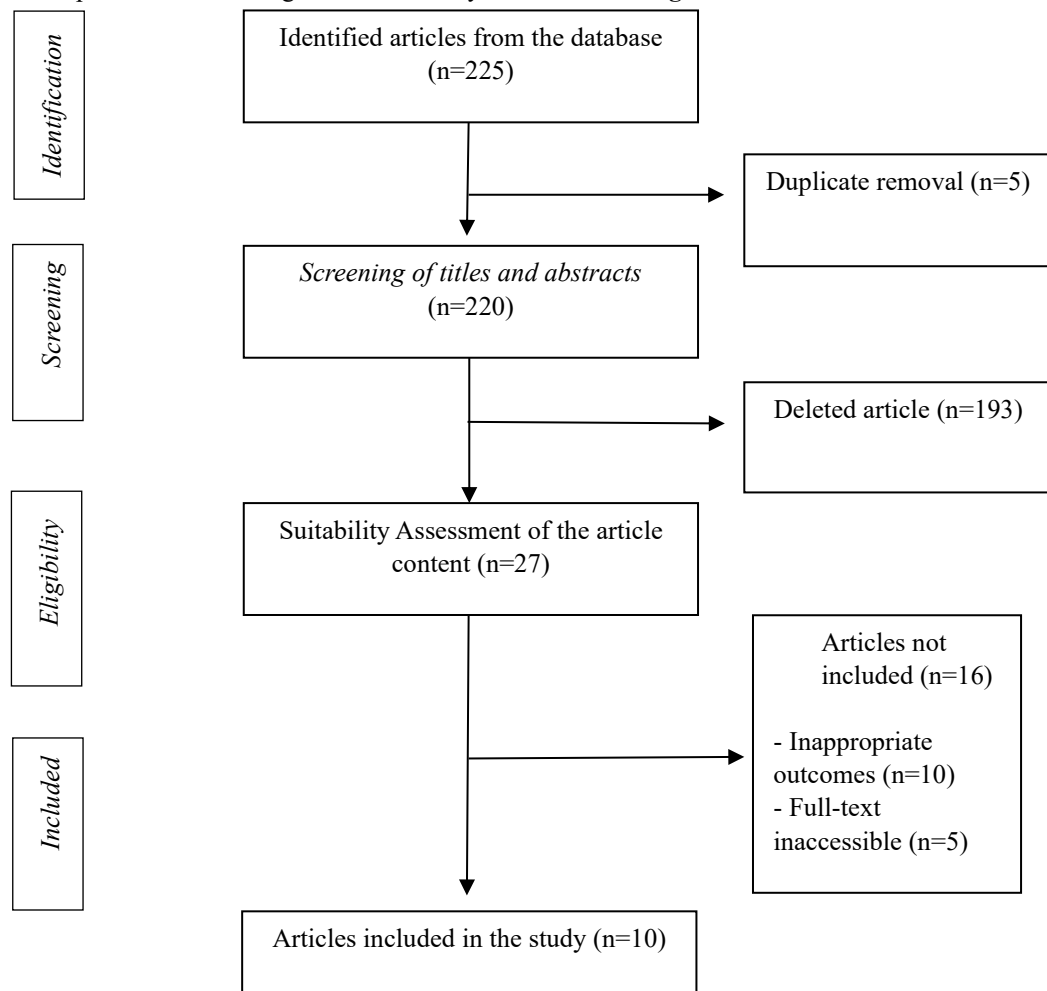


Fig. 1. Literature Search Flow Chart

3 Result

Based on the results of article selection, researcher found 10 articles for more in-depth analysis through systematic review. The review results are displayed in the Table 1 below:

Table 1. Article Included in the Research after Screening.

Journal Identity	Research Methods	Research Result
An assessment of dry hydrogen peroxide's ability to reduce microbiological in a healthcare setting [3]	Randomized Control trial	In many contexts, dry hydrogen peroxide has shown useful in lowering surface and air microbial contamination in sizable tertiary care facilities.
Using 0.5% hydrogen peroxide wipes, disinfect blood pressure cuffs and electrocardiogram telemetry leads [10]	Randomized Control trial	Wiping with a 0.5% hydrogen peroxide wipe is sufficient to sterilize the blood pressure cuff, thereby reducing the rate of bacterial and viral infections.
Hospital-acquired Infection Rate Was Lower When Daily Disinfectant Cleaner Was Used Instead of Daily Cleaner [11].	Randomized Control trial	Hydrogen peroxide disinfectant cleaning has advantages over simply wiping with alcohol in eliminating environmental reservoirs and reducing hospital-acquired infections (HAIs) caused by <i>C difficile</i> , MRSA, and VRE.
At a pediatric oncology hospital, the effect of hydrogen peroxide on hospital-acquired infections [12]	Randomized Control trial	The decrease in HAIs in the PICU has been facilitated by the adoption of dry hydrogen peroxide as a cleaning and disinfection method.. In addition, it can be used as a manual cleaner to reduce the risk of infection due to environmental pollution.
An interrupted time series analysis was used to control methicillin-resistant <i>Staphylococcus aureus</i> (MRSA) in a hospital and examine the function of hydrogen peroxide decontamination [13].	Randomized Control trial	The use of hydrogen peroxide disinfection resulted in decreased decontamination of residual MRSA in patient rooms compared with detergents.
Quaternary ammonium compounds are less effective than hydrogen peroxide and sodium hypochlorite disinfectants against biofilms of <i>Staphylococcus aureus</i> and <i>Pseudomonas aeruginosa</i> . [14]	Randomized Control trial	Sodium hypochlorite and hydrogen peroxide disinfectants have much higher bactericidal efficacy than quaternary ammonium chloride disinfectants.
The effectiveness of hydrogen peroxide dry mist as an adjuvant method for disinfecting noncritical medical equipment has been studied [8].	Randomized Control trial	A dry mist of hydrogen peroxide may be an additional disinfection method to prevent transmission of infection to noncritical medical equipment.
Hybrid Hydrogen Peroxide Fogging for Enhanced Disinfection in a Critical Care Environment [15]	Randomized Control trial	Hybrid hydrogen peroxide fogging is effective in reducing the biological load on surfaces, so it can be applied in critical care patient rooms for infection prevention.
Does Hydrogen Peroxide Exposure on Repeat Lead to <i>Candida Auris</i> Resistance? [9].	Randomized Control trial	Adding H ₂ O ₂ solution to regular procedures will raise disinfection standards against

Journal Identity	Research Methods	Research Result
		Candida auris, increase patient safety, and save medical expenses.
N95 Respirators are Decontaminated with Hydrogen Peroxide Vapor for Reuse [16].	Randomized Control trial	Hydrogen peroxide vapor decontamination can be used to remove infections on N95 masks. However, its application is only allowed a maximum of 3 times on each mask to prevent a decrease in the filtration power of the mask.
Hydrogen Peroxide's Effect on Postoperative Drainage Reduction and Anti-infection in Multi-segmental Lumbar Surgery [17]	Randomized Control trial	In multi-segmental lumbar surgery, hydrogen peroxide can decrease the volume of postoperative drainage and the incidence of postoperative infection.

A detailed risk assessment of each study reviewed in Table 1 was carried out using the JBI critical appraisal checklist for Randomized Controlled Trial studies.

4 Discussion

Healthcare-associated infections, also known as nosocomial infections (HAIS), are illnesses that patients get while receiving treatment in hospitals and other healthcare facilities where there is no infection present at the time of admission and no incubation period [18]. Nosocomial infections are those that affect patients while they are receiving treatment in hospitals and other healthcare facilities but did not exist when they were admitted or during the incubation period. These include infections that developed while the patient was in the hospital but manifested themselves after they were discharged, as well as infections that hospital staff and other healthcare workers contract while performing their duties and are connected to the delivery of healthcare services in healthcare facilities. Healthcare-associated infections (HAIS) arise due to exposure to infections both from decreased immunity and the healthcare process of health workers. Intrinsic factors are disease severity, endogenous flora, age, genetic syndrome, immunocompromised condition, and malnutrition. Conversely, the use of invasive devices (such as urine catheters, central venous catheters, and mechanical ventilators), the inappropriate use of antibiotics, and a crowded atmosphere are extrinsic factors in the occurrence of nosocomial infections.

The goal of HAI prevention is to increase patient safety and lessen the effects of systemic infections [19]. Interventions that can be used to stop the spread of multi-resistant organisms (MROs) and prevent HAIs include alcohol-based disinfection and decontamination, adding hydrogen peroxide to the sterilization process, designing medical devices, educating and training medical staff, and creating standard procedural protocols [4]. Since hydrogen peroxide can destroy microorganisms in water, air, and land, it is the most popular option for decontamination since it improves patient safety and lowers medical expenses [9].

The hydrogen peroxide used in the recommendation process can be liquid, vapor, or solid. Hydrogen peroxide can be used in the decontamination process of medical equipment. Wiping with a 0.5% hydrogen peroxide wipe is sufficient to sterilize the blood pressure cuff, thereby reducing the number of bacterial and viral infections [10]. A dry mist of hydrogen peroxide can be an additional disinfection method to prevent the transmission of infections to non-critical medical equipment [8]. Dry Hydrogen Peroxide has been effective in reducing air and surface microbial contamination in a variety of situations in large tertiary care hospitals [3]. Hydrogen peroxide disinfectant cleaning has advantages over simply wiping with alcohol in

eliminating environmental reservoirs and reducing hospital-acquired infections (HAIs) caused by *C. difficile*, MRSA, and VRE [11]. In addition, hybrid hydrogen peroxide in the form of fogging is effective in reducing the biological load on surfaces, so it can be applied in critical care patient rooms for infection prevention [15].

With the chemical formula H_2O_2 , hydrogen peroxide is an organic molecule with potent oxidizing abilities. Physically, hydrogen peroxide is a liquid substance that dissolves readily in water, has a sour smell, and is available in a range of quantities. Nonpolar hydrogen bonds, which are absent from water, are formed by the covalent bonds in the H-O-O-H structure. Thermodynamic instability causes hydrogen peroxide to break down into oxygen and water. Apart from that, hydrogen peroxide contains hydrogen disulfide, hydrazine, hydroxylamine, and diphosphate [20]. In the medical world, hydrogen peroxide is used in the process of eliminating infections. Hydrogen peroxide has an oxidative effect on microbes which disrupts microbial structure and function, resulting in microbial death [3]. The effectiveness and safety of using hydrogen peroxide in the process of decontaminating medical equipment for patients, equipment, and medical personnel can reduce HAIs levels and improve health services.

5 Conclusion

Hydrogen peroxide has the highest effectiveness in the process of decontaminating medical devices against Health-care Associated Infections (HAIs) because they can kill microorganisms in water, water, and land, thereby increasing patient safety and reducing healthcare costs. It is envisaged that by using hydrogen peroxide in the decontamination process, the research findings can serve as an alternate source of reference in the fight against healthcare-associated infections (HAIs) in hospitals.

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