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Global Practices in Hospital Sanitization During the COVID-19 Pandemic

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Abstract

Introduction: A variety of environmental disinfection approaches, including chemical, physical, and radiation methods, as well as their combinations, have been adopted to mitigate the spread of COVID-19. This summary reviews the latest findings on the efficacy of different disinfection strategies in the context of hospitals.

Methods: Research was conducted using the search terms (COVID-19 OR corona OR MERS-CoV-2) AND (disinfect* OR UV OR Ozone OR Chlorine) within titles and abstracts. Additionally, studies on COVID-19 (SARS-CoV-2) disinfection practices in dental clinics were reviewed. The search highlighted five main categories of disinfectants: Bleach (chlorine-based), alcohol, UV light, Hydrogen peroxide, and various others (such as ethylene oxide, glutaraldehyde, quaternary ammonium, chlorhexidine gluconate, povidone iodine, and peroxyacetic acid), utilized across various settings.

Results: Out of an initial pool of 320 articles, 60 were deemed directly relevant. From these, 21 were chosen for their detailed descriptions of disinfectant types and applications after title and abstract screenings. Two authors independently reviewed the full texts, extracting and summarizing the data on disinfectant use in various environments.

Conclusions: Common disinfectants like alcohol and chlorine-based solutions are highly effective against SARS-CoV-2. The most effective methods for neutralizing viruses, including SARS-CoV, in hospital wastewater are Chlorine, Sodium hypochlorite, Chlorine dioxide, Ozone, and UV irradiation.

Keywords: ***COVID-19, Disinfectant, Chemical, Radiation, Saudi***

Introduction

Since its onset in 2020, COVID-19, caused by the SARS-CoV-2 virus, has triggered multiple waves of epidemics [1]. An individual infected with COVID-19 can release approximately 3000 respiratory droplets across a broad spectrum of sizes (from 0.1 to 100 micrometers) through coughing [2]. It's critical to understand that even a 4-log reduction in viral load on surfaces doesn't eliminate the risk of infection, highlighting the importance of maintaining distance from anyone exhibiting COVID-19 symptoms, including coughing, sneezing, fever, and difficulty breathing, as advised by health authorities [3]. Recent research has detected SARS-CoV-2 RNA in municipal wastewater across various nations, although there's no confirmed case of transmission through water [4].

The detection of SARS-CoV-2 RNA in sewage provides a crucial early warning of COVID-19 presence within communities, suggesting that sewage surveillance could potentially facilitate the early identification of infected individuals. For instance, Randazzo et al. found SARS-CoV-2 RNA in sewage before the official reporting of cases, indicating wastewater surveillance as an effective early detection tool [5]. This method, known as Wastewater-Based Epidemiology (WBE), benefits from the increased viral load in wastewater correlating with the rise in COVID-19 cases. However, the application of WBE faces challenges, including inconsistent detection methods that sometimes yield contradictory results.

Comparisons between grab and composite wastewater samples have shown differences, with some studies recommending composite samples for more reliable data. While most WBE studies focus on wastewater, research by Balboa et al. suggests that sludge may be a better medium for virus detection due to its tendency to attract enveloped viruses [6]. The absence of SARS-CoV-2 detection in some studies due to low infection rates underscores the need for further research to improve detection sensitivity, as explored by Hata et al. [7]. Despite some studies showing a correlation between wastewater SARS-CoV-2 levels and confirmed cases, others do not, highlighting the large complexity of WBE. Furthermore, there are recommendations for thorough cleaning and disinfecting of surfaces in both public spaces and medical settings. Disinfecting wipes with quaternary ammonium compounds have proven effective against the virus [8], and UV irradiation and heat have been suggested for wastewater treatment in hospitals to minimize by-products and maximize disinfection efficacy. Governments are urged to enhance waste and wastewater management in healthcare facilities during the pandemic [9]. The recent surge in UV disinfection for air and surfaces reflects its significance in controlling the spread of COVID-19, emphasizing the role of no-touch disinfection technologies in sanitizing public transportation and healthcare environments. This review compiles and evaluates the latest advancements in disinfection strategies within hospital settings amid the ongoing pandemic [10].

Methods

The following search term was used: (COVID 19 OR corona OR MERS-CoV-2) AND (disinfect* OR UV OR Ozone OR Chlorine) in the title and abstract. A literature search was also performed to retrieve study articles regarding Covid-19 (SARS-CoV-2) and disinfection in dental clinics. The initial search identified 320 articles and then 60 articles that were closely relevant to our subject were selected. After the screening of the titles and abstracts of these articles, 21 articles which include clear information about the types and application of different disinfectants were selected and the full text of them evaluated by two of authors independently. Then the results of these articles extracted and the types of disinfectants which used in different places were determined and summarized. The final search identified that five groups of disinfectants include: Bleach (chlorine containing disinfectants), alcohol, UV irradiation, Hydrogen peroxide, and other disinfectants (e.g., ethylene oxide, glutaraldehyde, quaternary ammonium disinfectants, chlorhexidine Gluconate, povidone iodine, peroxyacetic acid etc.) were used against COVID-19 in different spaces.

Results and discussion

Many methods of environmental disinfection were used to reduce the risk of COVID-19 transmission including chemical, physical, radiation and combinations of these methods. Chlorine has high reactivity with amino acids and proteins and has a strong capability to inactivate viruses. With rapidly decreasing access of commercial disinfectants, diluted bleach can efficiently disinfect our homes, clinics, and environment to prevent continuous transmission from inanimate items. By obtained results from other coronaviruses, experts are assured that 0.1% sodium hypochlorite could inactivate the virus. These low dilutions of sodium hypochlorite are clinically effective with negligible irritation and it's better to be used within one month of preparation and kept in a closed, impervious container at room temperature [11]. Compared with chlorine disinfection, the investment and operation costs of UV disinfection are significantly lower.

In addition UV irradiation and heating are also suggested for wastewater disinfection in other COVID-19 designated hospitals because of fewer by-products and ideal disinfection performance. Ultraviolet light (UV) refers to the electromagnetic wave with length between 200 nm and 400 nm. The UV was first used in disinfection of drinking water in 1910 [9]. Disinfection could therefore be achieved using 30 min at 56 °C, ether, 75% ethanol, chlorine-containing disinfectants, peracetic acid, or chloroform. Floors of all zones were disinfected twice daily by spraying 1000 mg/L chlorine-containing disinfectants. For areas other than the treatment rooms, air disinfection was conducted using electric ultra-low capacity sprayers with 3% hydrogen peroxide, 5000 mg/L peroxyacetic acid, 500 mg/L chlorine dioxide, and other disinfectants. The areas were then fully ventilated after the disinfection was complete (the time of action of hydrogen peroxide and chlorine dioxide is 30-60 min, and that of peroxyacetic acid is 1 hour [12]. Many treatment technologies of hospital wastewater were investigated by different studies such as ultraviolet irradiation, coagulation-filtration and biocidal agents as gaseous ozone, alcohol, formaldehyde, hydrogen peroxide, peroxyacetic acid, povidone iodine and chlorine-based disinfectants [13].

On the other hand reported that the efficient technologies of deactivation of viruses as SARS-CoV from hospital wastewater are Chlorine (Cl_2) Sodium hypochlorite (NaOCl) Chlorine dioxide (ClO_2) Ozone (O_3) and UV irradiation [14]. chlorine-based disinfectants are widely used for their broad sterilization spectrum, high inactivation efficiency and easy decomposition with little residue, as well as represents the best economic solution. However, excess use of chlorine-based disinfectants can generate more than 600 kinds of disinfection by-products, which are harmful to ecosystems and human health. n the other hand, chlorine reacts with ammonia contains in wastewater and forms a new product (chloramine), which behaves differently to free chlorine during disinfection. However, chlorine dioxide was less effective for the inactivation of SARS-CoV than chlorine.mg L^{-1} of chlorine dioxide (2.19 mg /L of free residual chlorine) can inactive completely SARS-CoV about 30 min [12].

Far UV-C light at 207-222 nm induced 99.9% inactivation of the airborne βHCoV-OC43 strain in 25 min, and presumably would have a similar effect on the SARS-CoV-2. Studies conducted with UV-C indicate that a dose ranging from 3.7 mJ/cm ^{2} to 10.6 mJ/cm ^{2} should inactivate the viruses in 5 min. These alternative methods could be used during commercial shortages of UV devices due to COVID-19. UV light irradiation and in combination with metal ions, e.g. This limitation can be overcome by use of "no-touch" (automated) disinfection approaches such as hydrogen peroxide vapor and ultraviolet light (UV) [15].

Hydrogen peroxide vapor has been widely used for disinfecting coronaviruses. UV disinfection devices contain either a mercury-based source or pulsed-xenon bulb source to generate UV rays. Inhibition of the Middle East respiratory syndrome coronavirus (MERS-CoV) was done by 5 min application of UV-C from an automated whole-room. Recently, a pulsed-xenon-based UV device demonstrated 4.2 $\log_{10}$ reduction on hard surfaces and 4.79 $\log_{10}$ and reduction on N95 respirators following 5 min of exposure. UV-A has been shown to have a weaker effect even after 15 min of exposure, suggesting that

UV-C is more potent. Viral survivability depends on many factors such as wavelength, dose, distance and duration of UV radiation, which should be studied and tuned prior to use in healthcare and other non-healthcare settings [16]. It was demonstrated that UV-B (315-280 nm) and UV-C (190-290 nm) cause a significant and rapid decrease in infectious SARS-CoV. However, if this behavior occurs, it is evident to take into account the variation of season and geography in UV light availability. According to previous studies, the exposure to UV light can also decrease the activity of coronavirus, especially SARS-CoV, in aquatic environment [17]. The effectiveness of UV light in the inactivation of SARS-CoV-2 is not yet explored to date. The infectivity of SARS-CoV-2 in wastewater has not been assessed, even though culturable viral particles have been detected in the feces of infected individuals. It indicated that the survival of the viruses decreased drastically when the parameters such temperature UV-light and organic matter were unfavorable. On the other hand, previous studies reported that the efficient technologies of deactivation of viruses as SARS-CoV from hospital wastewater are Chlorine (Cl_2) Sodium hypochlorite (NaOCl) Chlorine dioxide (ClO_2) Ozone (O_3) and UV irradiation [18]. The competing processes of ozone generation and dissociation from and to molecular oxygen catalyzed by deep UV irradiation is described in the literature extensively. It is known that radiation in the far-UVC region is capable of generating ozone via photolysis of environmental oxygen molecules [19]. Therefore, systems designed to apply far-UVC radiation for air disinfection could generate ozone during their operation.

The risk posed by this generation is a function of the UV source power output and its emission spectrum, as well as air flow or stagnation and operation duty cycle [10]. Therefore, as a conservative technique, the UV surface disinfection systems should be designed based on a high situation. Based on the available data, the authors of this article hold the opinion that the SARS-CoV-2 can likely be categorized with SARS-CoV-1 as a mildly resistant virus to UV radiation, similar to the hepatitis A virus, influenza virus, and bacteriophage MS2. Over the last few months, a significant number of technical reports, news, and whitepapers have been released, claiming the eligibility of various UV disinfection systems and commercial products against SARS-CoV-2. While obtaining the reported UV doses for SARS-CoV-2 inactivation [20].

Conclusions

Due to the ability of SARS-CoV-2 to linger in the air and on surfaces from a few hours up to several days, alongside adhering to personal hygiene practices like frequent hand washing and minimizing contact within hospital environments, it is crucial to sanitize surfaces that are frequently touched to curb the spread of the virus. Commonly utilized disinfectants, such as those containing alcohol or chlorine, have been proven to effectively neutralize SARS-CoV-2. While bleach and alcohol have been the primary recommendations for disinfection, exploring the efficacy of alternative disinfecting agents is also important. Consequently, there is a pressing need for research into the susceptibility of SARS-CoV-2 to various disinfectants within specific hospital areas, aiming to develop safe and effective disinfection solutions.

Conflict of interests

The authors declared no conflict of interests.

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