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A narrative review on the application of sanitizers in the COVID-19 pandemic

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ABSTRACT

At the beginning of 2020, a new coronavirus, namely SARS-CoV-2, has started to spread worldwide leading to the so-called COVID-19 pandemic. The present study aims to review the effectiveness of disinfectants in the prevention and control of the COVID-19 pandemic. In this article, after an introduction to the COVID-19 pandemic, the role of disinfectants in the prevention and control of the COVID-19 pandemic is discussed. To identify the articles, English databases including Google Scholar, Scopus, Science Direct, Web of Science, and PubMed from December 2020 to November 2020 were examined using keywords. There is also a manual search in journals, a collection of abstracts in conferences, and conferences and dissertations. Hand hygiene is a well-accepted principle in preventing the transmission of most infectious diseases. Given that many formulations of sanitizers can be effective against COVID-19, it may alter the integrity and function of the skin barrier and increase the risk of dermatitis on the hands.

1. Introduction

World Health Organization (WHO) declared COVID-19 as a pandemic on March 11, 2020. The global infection rate of COVID-19 is increasing sharply. Coronaviruses (CoV) represent a diverse and large family of enveloped and single-stranded RNA viruses (1). The structure of This family can cause a variety of illnesses in humans and animals including Severe Acute Respiratory Syndrome (SARS), Middle East respiratory syndrome (MERS), and COVID-19 (2). Coronaviruses comprise alpha, gamma, beta, and delta groups with 22 subclasses and 40 species (3). The structure of COVID-19 is shown in Fig. 1. The spike proteins are responsible for the synthesis of RNA, whereas membrane and envelope proteins are associated with viral assembly (4). The common symptoms of COVID-19 disease are pneumonia, acute respiratory disease, fever, and dry cough. However, this disease may infect people in an asymptomatic form. Given that millions of people are receiving the vaccine, however, there are no medications to treat COVID-19 disease and a new highly contagious mutated form of coronavirus is emerging. Several mitigation policies including city lockdowns and social distancing have been implemented by the governments (4). Personal and social preventive measures slowdowns the super spread of the pandemic until effective drugs become available and vaccination is done (5). WHO has recommended people have a healthy lifestyle, strengthen their immune system, wear masks and disinfect hands with soap or alcohol-based sanitizers. In this review, the role and mechanism of disinfectants against coronavirus are briefly discussed.

2. Use of hand hygiene products

Hand hygiene as a principle can decrease the spread of respiratory diseases and the COVID-19 pandemic (6, 7). Given that hand hygiene practices are easy and inexpensive, however, compliance with handwashing differs from approximately 2 to 78% among various populations and

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contexts (8, 9). Perception and effectiveness of hand hygiene performance are associated with many factors including gender distinction (10, 11). Girls have shown 1.12 times the likelihood of excellent handwashing compared to boys (12).

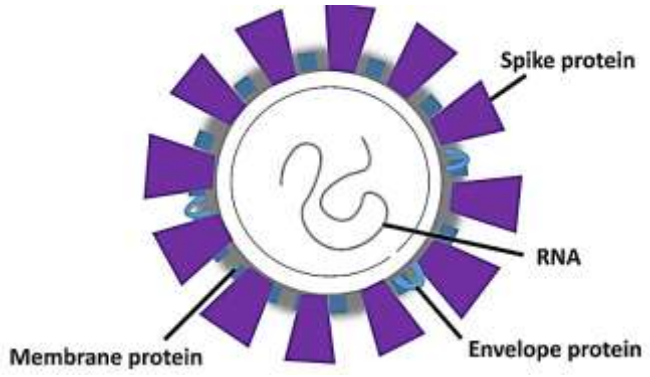

Fig. 1. Structure of COVID-19 (4).

Soap as a fatty acid salt has cleansing properties that remove viruses by disrupting intracellular and membrane lipids. However, frequent washing with water and soap can lead to irritation and skin sensitivity due to damage to keratin proteins and removal of intracellular lipids which are in the stratum corneum of the skin (13, 14). However, several factors other than harsh soaps and potent detergents such as water hardness, rubbing with rough paper towels, wet work, low humidity, working with irritants, and hot or very cold water can affect the function of the skin barrier (15, 16). American Contact Dermatitis Society declared that irritant contact dermatitis and allergic contact dermatitis increases during the COVID-19 pandemic by stringent hand hygiene (14). As reported, health care workers wash their hands more than ten times every day and only a few of them use moisturizers after washing their hands which leads to hand dermatitis (6, 17, 18). As reported by Derksen et al. (19) hand hygiene performance has increased from 47 to 95 percent after lockdown during the COVID-19 pandemic. Taghrir et al. (20) study assessed the knowledge, self-report preventive behaviors (hand washing and surface disinfection), and risk perception related to COVID-19, among Iranian medical students in the first week after the Covid-19 outbreak in Iran. This cross-sectional study was conducted from February 26 to 28, 2020. Participants were Iranian medical students (fifth to the seventh year) whose knowledge, preventive behaviors (hand washing and surface disinfection), and their perception of COVID-19 risk were assessed using an online questionnaire. The questionnaire consisted of 26 questions including 15 questions about knowledge and awareness related to COVID-19, 9 questions about preventive measures (hand washing and disinfection of surfaces), and 2 questions about risk perception related to COVID-19. The validity and reliability of the questionnaire were satisfactory. A total of 240 medical students completed the questionnaire. The results showed that the mean age of the participants was 23 years. The mean of correct knowledge responses was 96.86% and 79.60% of the participants had high awareness. The average rate of preventive behaviors was 94.47%. and 94.2% had good performance in preventive behaviors (hand washing and surface disinfection). The cumulative risk perception was 4.08 out of 8, which was moderate. There was a statistically significant difference in risk perception between interns and trainees as well as between those trained in the emergency and non-emergency departments. There was a negative correlation between preventive behaviors (hand washing and surface disinfection) and risk perception. There was also a high level of knowledge and awareness related to COVID-19 and self-reported preventive behaviors (hand washing and surface disinfection) and risk perception among Iranian medical students. The study by Moore et al. (21) aimed to investigate the effect of the COVID-19 pandemic on hand health performance (HHP) in acute care hospitals in the United States. The increase is discussed and then decreases as it progresses. In this paper, hand hygiene performance (HHP) rates were assessed using an automatic hand hygiene monitoring system in 74 adult admission wards in 7 hospitals and 10 pediatric admission units in 2 pediatric hospitals. A regression model was used to estimate hand hygiene performance rates at 10 weeks leading up to a significant COVID-19 event (e.g., school closure) and for 10 weeks thereafter. Various analyzes were performed and several scenarios were studied to elucidate the effect of the parameters on the possible outcomes. Data from an automated hand hygiene monitoring system showed that hand hygiene performance in the early stages of the epidemic has changed in several directions. Three effects emerged that were all significant at $p<0.01$. The results showed that the average rate of average hand hygiene performance in the months before the school closure related to the start of the epidemic increased from 46 to 56. At the time of school closure, there was a 6% upward shift. The hand hygiene performance rate remained more than 60% for 4 weeks before decreasing to 54% at the end of the study period. The study conducted by Derxen et al. (19) studied the adherence and evaluating the determining factors in obstetric and gynecological hospitals during and after COVID-19 in Germany. In this article, a total of 267 behavioral observations were made in two hospitals of the German University of Obstetrics and Gynecology in three time periods (before the COVID-19 pandemic, increased awareness and careful precautions). In addition, 115 health workers answered questionnaires about the social cognitive determinants of hand health behavior. Multiple regression was used to analyze the relationships. Findings showed that adherence to hand hygiene recommendations increased from 47% of cases before the COVID-19 pandemic to 95% just before the restrictions (although simple anti-epidemic measures were taken). Self-efficacy was associated with the intention to follow hand disinfection instructions ($b = 0.397$, $p <0.001$). Obstetricians and gynecologists appear to adapt their hand disinfection behavior to prevent infections in the COVID-19 pandemic. To further improve preventive interventions, cognitive-social determinants, especially behavioral intent and self-efficacy, must be considered. The study by Chen et al. (12) aimed to understand the health status of handcuffs and masks among primary school students during

the 2019 Coronavirus (COVID-19) pandemic in Wuhan, China. In this paper, logistic regression analysis was used to identify risk factors affecting handwashing behaviors and mask use. The results showed that 42.05% of primary school students showed good handwashing behavior, while 51.60% had good behavior in using the mask. Gender, educational background, educational background, father's job, mother's educational background and time to complete the survey were significantly related to hand health, while educational background, mother's education was related to mask-wearing behavior. Hand-washing and masking behaviors among primary school students are influenced by gender, grade, and other factors, so parents should follow their instructions, while governments should provide general advice on hand-washing and masking behaviors. The synthetic detergents which are a mixture of petrolatum and surfactants have a similar pH to the skin (5.5-7) and contain less than 10 percent of soap (13). Synthetic detergents such as glucosides, cocamide diethanolamine, and sodium cocoyl glutamate can disrupt the viral membrane of lipid enveloped viruses (22, 23). The concentration of surfactants is an important factor for irritation, inflammation, and skin xerosis (13, 14). Antiseptic handwashes are soaps and synthetic detergents that have antimicrobial agents that disrupt the integrity of the viral membrane. For example, alcohol denatures proteins or povidone iodine impairs protein synthesis by penetrating to cells and inactivating the cellular replication (14). The hand wipes contain antimicrobial agents such as alcohol and benzethonium chloride which disrupt the integrity and viral membrane of enveloped viruses (14). It worth mentioning that surface wipes should not be used for skin wipes as they contain harsh antimicrobial agents like N-alkyl dimethyl benzyl ammonium chloride (24). The Centers for Disease Control and Prevention has recommended using alcohol-based sanitizers that contain moisturizers and emollients with low allergenicity instead of harsh soaps and synthetic detergents to prevent contact dermatitis (25, 26). The alcohol-based sanitizers contain ethanol, isopropanol, and hydrogen peroxide portfolio (27). The high-touch surfaces should be disinfected. After cleaning and removal of organic matters from surfaces by brushing and using soap and water, disinfectants can be used to kill any residual microorganisms (28, 29). It should be noted that fogging/spraying of chemical disinfectants such as quaternary ammonium compounds, chlorine-based agents, and formaldehyde for removal of COVID-19 from environmental surfaces is not recommended due to their adverse health effects (30). As reported by Slaughter et al. (31), alcohol-based sanitizers can also have toxic adverse impacts on the environment after evaporation. In the first five months of 2020, the Pesticide Control Association reported 9504 cases of contact with alcoholic disinfectants in children under 12 years of age. Even small amounts of alcohol can cause alcohol poisoning in children, causing dizziness, vomiting, drowsiness, and in severe cases, respiratory arrest and death (32). Disinfectants including isopropanol, hydrogen peroxide, formaldehyde, iodophors, and ethanol can cause respiratory and non-respiratory problems such as gastrointestinal effects, skin and eye irritation, dermatitis, liver damage, and central nervous system depression (33, 34). For example, skin absorption of ethanol-based disinfectants via occupational exposure and frequent use of hand sanitizers can cause poisoning (34). On the other hand, skin as a barrier to viruses and bacteria can become more susceptible to many infections and diseases due to the use of disinfectants that remove skin oil and increase skin permeability (28). It has been reported that excessive use of alcohol-based disinfectants can increase the risk of viral outbreaks (35). To avoid these adverse health problems, technologies without direct exposure to disinfectants such as irradiation with UV, aerosolized hydrogen peroxide, gaseous ozone, and pulsed xenon have been proposed (36). It is recommended that if cleaners are in direct contact with disinfectants and contaminated surfaces, personal protective equipment (PPE) like gowns, masks, and face shields should be used (30). As COVID-19 can be transmitted via air, it is important to use PPE for safety. The type and concentration of disinfectant for high-touch surfaces like food preparation areas should be carefully selected to prevent adverse health effects and avoid damaging the food surfaces (28).

3. Mechanism of action of some disinfectants on coronavirus and other enveloped viruses

The spherical coronavirus as an enveloped virus with an outer lipid layer is more sensitive to disinfectants than non-enveloped viruses (28). The antigenic proteins of the outer surface envelope attach to specific receptors of the host. The virus enters the host cell and replicates by integrating with the genetic RNA code (37). The alcohol-based disinfectants containing ethanol penetrate the membrane and denatures the protein tertiary structure by the breakdown of hydrogen bonds (38). Ethanol is more effective against hydrophilic viruses such as COVID-19, rotavirus, and human immunodeficiency virus (HIV) than isopropyl alcohol (28, 39). Isopropyl alcohol and ethanol exhibit 70-90% biocide properties against COVID-19 (30 sec) (38). Alcohol-based hand sanitizers consist of 60-95% alcohol (40). The carcinogenicity of alcohol-based disinfectants through skin absorption is still unknown (41). Alcohol toxicity can cause hypophosphatemia, hypomagnesemia, hypocalcemia, myoglobinuria, respiratory depression, and acute liver damage (42, 43). Determination of the toxic concentration of ethanol-based hand rub is difficult due to different tolerance levels and reactions to ethanol in different people (32). It should be noted that oral consumption of alcohol through alcohol-based sanitizers, alcohol-containing cosmetics, and mouthwash can cause toxicity (44). Dermal exposure to ethanol leads to allergic responses and drying and cracking of the skin which can be reduced by the application of combined components with ethanol such as panthenol to regenerate the skin barrier or glycerol for the hydration of skin (45). Peroxide-based disinfectants such as peroxy-acetic acid and hydrogen peroxide affect nucleic acid, protein, and lipid membrane of viruses via producing hydroxyl free radicals (46). Hydrogen peroxide at 1-3 % levels oxidizes

disulfide bonds of thiol groups in proteins and inactivates SARS-CoV (28). The hypochlorous acid (HOCl) as a solution of sodium and calcium hypochlorite exhibits extensive antiviral activity. Given that hypochlorite reacts and inactivates in exposure to organic matters, surfaces should be mechanically cleaned with detergents or soap and water before application of these disinfectants (47). The activity of chlorine solution is higher at lower pH values. However, the shelf life of low pH chlorine solution is shorter than high pH chlorine solution and should be prepared fresh for use (48). WHO has declared that chlorine-based disinfectants kill 99% of viruses (49). Alkyl dimethyl ammonium chloride biocide as a quaternary ammonium compound in a low concentration of 1 % is efficient against COVID-19 in less than 1 minute (38). As reported by Kariwa et al. (50) formaldehyde and glutaraldehyde can alkylate the bacterial proteins and nucleic acid at concentrations of 0.5-3%. Povidone-iodine as an antiseptic agent for viruses can damage nucleic acid and break down the disulfide bonds in proteins which can inactive SARS-CoV at a concentration of less than 1% (51). Health care workers have improved their hand hygiene behaviors to protect themselves and their families from this COVID-19 pandemic (52). Given that emphasizing the importance of hand hygiene improves hand hygiene performance (21), in the food industry, perception of personal risk and self-protection is not a driver for hand hygiene and there should be other reasons for a good hand hygiene performance (53).

4. Conclusion

It is recommended to wash hands with antimicrobial soaps to eliminate possible infection with COVID-19 disease. However, the excessive use of hand sanitizers as a preventive measure against COVID-19 is not environmentally friendly and is dangerous to human health. To date, no drugs are available to combat COVID 19 infection, and the rate of infection is rising sharply worldwide. The World Health Organization (WHO) has proposed only vaccination and preventative measures and a healthy lifestyle with an effective immune system to combat and stay safe from the pandemic. The World Health Organization recommends alcohol-based hand sanitizers for recurrent hand hygiene, which are mainly made from ethanol, isopropyl alcohols, and hydrogen peroxides with various compounds. The compounds of these substances may be toxic to human health and the environment, and if used improperly, these chemicals have toxic and dangerous effects on the environment that are released during evaporation. In addition, repeated use of hand sanitizers has increased the risk of antimicrobial resistance and other viral diseases.

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