

Alcohol-Based Hand Sanitizers: A Systematic Review on Effectiveness and Effects

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Abstract

Objective: The use and adverse effect of alcohol-based hand sanitizers as a preventive measure in combating the spread of COVID-19.

Materials and Methods: A literature search of the electronic databases including PubMed, Scopus, Research gate and Embase was conducted to retrieve articles investigating the protective effect of alcohol-based sanitizers against the spread of COVID-19 as well as its possible adverse effects. The search timeframe ranged from the inception of each database to August 2020.

Results: From an initial search of 456 articles, and after the removal of duplicates as well as applying the predetermined inclusion and exclusion criteria, 74 articles were finally included for this systematic review. Results showed promising protective effect of alcohol-based hand sanitizers against the spread of COVID-19 pandemic. Furthermore, no adverse effect was observed after the use of alcohol-based sanitizers though there are certain possible adverse effect identified which includes skin toxicity, risk of skin burn due flammability etc.

Conclusion: Alcohol based hand sanitizers are effective against lipophilic viruses which means they are effective against coronaviruses. To ensure efficacy of the product, the recommended ethanol concentrates should be strictly adhered to and regulated. Alcohol based hand sanitizers has few adverse effects ranging from skin toxicity when ethanol concentrates is relatively high and not regulated courtesy of proliferation of fake products in the market. They are known to be flammable in nature and can cause skin burn if the safety and precautionary instructions are not strictly adhered to. Hand hygiene and the use of alcohol based hand sanitizers are effective in preventing direct and indirect spread of COVID-19.

Keywords: Alcohol-based hand sanitizer • Pandemic • COVID-19 • Disinfectants • Disease prevention

Introduction

Many Countries including Nigeria focuses on regular hand washing practice and use of alcohol-based hand sanitizer as a means of preventing coronavirus spread [1]. This article focused on the use of alcohol based hand sanitizers and its effectiveness in the prevention of COVID-19 while also considering its adverse effects. COVID-19 (Coronavirus Disease-2019) pandemic is of great concern to public health. The use of alcohol based hand sanitizer is globally practiced in an effort to prevent rapid spread of the virus [2]. The total number of coronavirus cases in the world has risen to over twenty three million (23Million) [3]. Due to the contagious nature of the virus, the use of disinfectants such as alcohol based hand sanitizer becomes apparent. COVID-19 or n-COV 2019 is a contagious disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which can persist and remain infectious on surfaces for up to 9-14 days [1-3]. Studies have shown that the spread is rapid in confine space and crowd with the presence of an infected host. The agent is dispersed in the air when an infected person

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Received 01 September, 2020; **Accepted** 04 November, 2020; **Published** 11 November, 2020

sneezes or coughs. The virus is enveloped in the droplets for hours and can survive on surfaces for 24-48 hours [4]. The need to break the route of transmission becomes more apparent through early detection, contact tracing, isolation, use of nose mask or face shield, regular hand-washing practice and use of alcohol based hand sanitizer has been made primus-inter-pares among other measures put in place to prevent COVID-19 spread. Nigeria Centre for Disease Control (NCDC) encourages Nigerian citizens through daily text on the tips of preventing the virus spread. The use of alcohol based hand sanitizer was tipped as effective hand disinfectants against the spread of the virus. Due to this development; the demand for alcohol based hand sanitizers skyrocketed in commercial stores. Health institutions such as Ekiti State college of Health sciences and Technology Ijero Nigeria produced mini sanitizers courtesy of the Community Health department; there are also different brands of hand sanitizer proliferated in the market. Some of these sanitizers despite the hike prices are ineffective as they are not alcohol based. The World Health Organization (WHO) recommends alcohol-based hand sanitizer (ABHS) in line with the proven advantages of their rapid action and a broad spectrum of microbicidal activity to ensure protection against bacteria and viruses. However, the effectiveness against non-enveloped viruses is still debatable and questionable (Figure 1) [5-8].

Presently, according to World Health Organization, alcohol based hand sanitizers are the most effective formulations due to its capability to denaturalize proteins of microbes and making virus inactive [9,10]. Though alcohol based hand sanitizers are slightly flammable and could lead to skin toxicity when alcohol content is too high [11,12]. This systematic review will look into alcohol based hand sanitizers, their effectiveness and possible adverse effect.



Figure 1. Types of hand sanitizer.

Materials and Methods

Search strategy

The reporting of this systematic review was done in line with the statement of preferred reporting items for systematic reviews and meta-analyses (PRISMA) [13,14]. An electronic literature search was conducted in August 2020 using the following databases; PubMed, Scopus, and Embase for articles published in English language investigating the efficacy of alcohol-based hand sanitizers, without restriction on year of publication. The search keywords were as follows: "alcohol-based hand sanitizers" and "COVID-19". Manual screening of references of retrieved studies was conducted to also obtain relevant studies.

Inclusion criteria

The retrieved articles were included based on the following criteria:

- Studies that were conducted to determine the effectiveness of alcohol-based hand sanitizers which were published in English language;
- Studies that used alcohol-based hand sanitizers;
- Experimental and clinical studies with full texts.

Exclusion criteria

Studies were excluded based on the following criteria:

- Studies in which alcohol-based hand sanitizer was not used;
- Studies in which alcohol was used in combination with other agents;
- Studies that made use of other forms of reagents;
- Studies that evaluated the effectiveness of alcohol-based hand sanitizers with other reagents; and
- Conference abstracts, case reports, letters, review articles, editorials,
- Unpublished data, articles without full texts, and non-English articles.

Study selection

All articles retrieved from the electronic databases as well as manual searches were entered into endnote software (EndNote version X9, New York, NY, USA) for removal of duplicates. Thereafter, two authors (V.S.O. and A.T.A.) independently reviewed the titles and abstracts of the retrieved studies for eligibility. Studies were then selected based on the predetermined inclusion and exclusion criteria. For any disagreements concerning the inclusion of studies, all authors agreed on a consensus based on factual evidence.

Data extraction

The data from each eligible study were extracted and checked by the authors. The following information was carefully obtained from each included

study: first author name, subject, frequency of use as well as findings. Furthermore, these data were summarized and presented in a tabular form.

Results

The PRISMA flow diagram of our search results is shown in figure 1. Initial search gave a total of 456 articles, with the breakdown as follows: 430 articles were from the three electronic databases (PubMed, Scopus and Embase) and 26 articles obtained through a manual search. From these figures, 186 articles were retained after the removal of duplicates. Thereafter, following careful examination and screening of their titles and abstracts as well as the application of the inclusion and exclusion criteria, a further 98 records were excluded. The full texts of the remaining 88 records were assessed. We excluded 10 articles for non-English language publication, while 4 more articles were removed for not having full texts. Finally, a total of 74 studies were included in this systematic review. The included studies were published in between November 2019 to August 2020.

Study characteristics

The summary of included studies and characteristics is presented in Figure 2. These articles were published between November 2019 and August 2020, employed an experimental design.

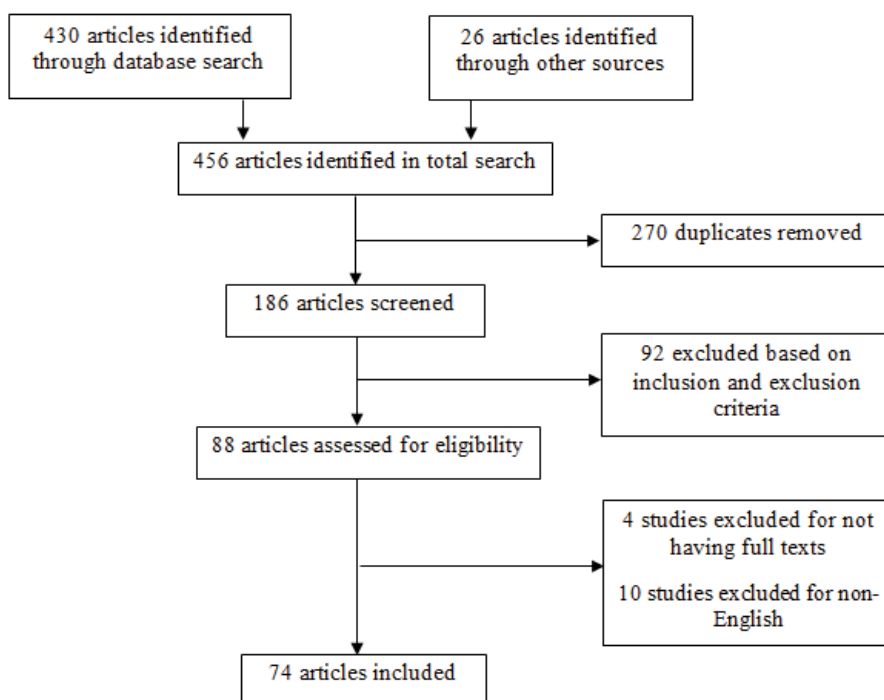


Figure 2. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram for the selection of included articles.

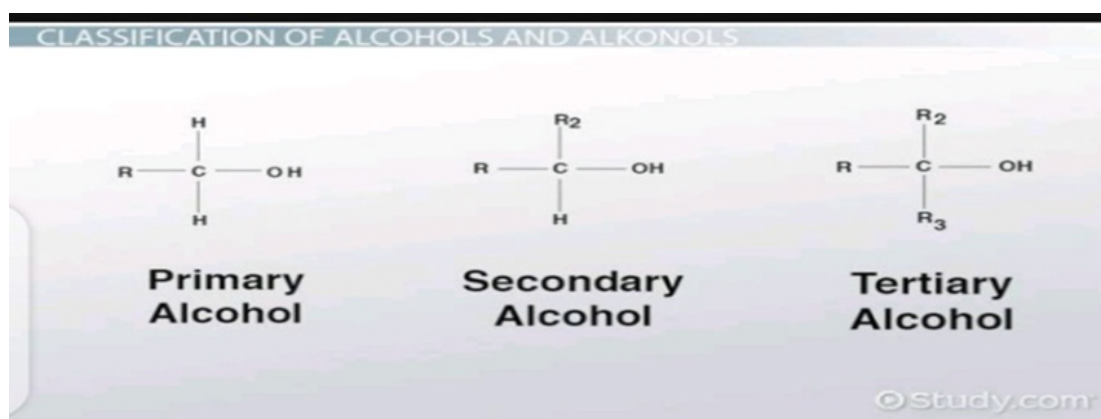


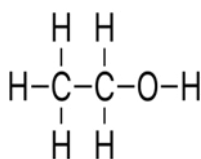
Figure 3. Classification of alcohols.

prefer the use of antiseptic and hand washing practice but the practice is often flawed [24]. The practice becomes easier when alcohol based hand sanitizers are used as it does not waste time.

Different constituents alcohol based hand sanitizers

Ethanol: Ethanol is a chemical compound, a simple alcohol with the chemical formula C_2H_6O . Its formula can be also written as CH_3-CH_2-OH or C_2H_5OH , and is often abbreviated as EtOH. Ethanol is a volatile, flammable, colorless liquid with a slight characteristic odor.

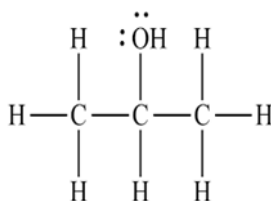
- Formula: C_2H_5OH
- Boiling point: $78.37^\circ C$
- Molar mass: 46.07 g/mol
- Density: 789 kg/m^3
- IUPAC ID: ethanol
- Melting point: $-114.1^\circ C$



Ethanol is an important industrial chemical; it is used as a solvent, in the synthesis of other organic chemicals, and as an additive to automotive gasoline (forming a mixture known as a gasohol). Ethanol is also the intoxicating ingredient of many alcoholic beverages such as beer, wine, and distilled spirits.

Isopropanol: Isopropyl alcohol is a colorless, flammable chemical compound with a strong odor. As an isopropyl group linked to a hydroxyl group, it is the simplest example of a secondary alcohol, where the alcohol carbon atom is attached to two other carbon atoms. It is a structural isomer of 1-propanol and ethyl methyl ether.

- Formula: C_3H_8O
- IUPAC ID: isopropyl alcohol
- Boiling point: $82.5^\circ C$
- Density: 786 kg/m^3
- Molar mass: 60.1 g/mol
- Melting point: $-89^\circ C$

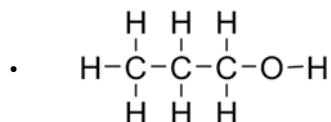


Isopropanol is used in soaps and lotions as an antiseptic. Isopropyl alcohol or 2-propanol is an isomer of 1-propanol. It is a colorless liquid having disinfectant properties. It is used in the manufacture of acetone and its derivatives and as a solvent. [26,27].

Propanol: Propanol is a primary alcohol with formula CH_3CH_2OH . This colorless liquid is also known as propan-1-ol, 1-propyl alcohol, n-propyl alcohol and n-propanol. It is an isomer of 2-propanol

- Formular: C_3H_8O
- Molar Mass: 60.0952 g/mol
- Boiling Point: $97^\circ C$
- IUPAC ID: Propan-1-ol
- Density: 803 kg/m^3

- Melting Point: $-126^\circ C$ [28]



About 65% - 90% of alcohol concentrates in a given hand sanitizer is effective to destroy or act against microbes as the lipid membranes of microbes are altered [29]. Alcohols have broad-spectrum antimicrobial activity against bacteria, viruses, fungi etc. though they can be less effective when it comes to protozoa [30]

Effectiveness

Alcohol based hand sanitizers are available in market stores, pharmacy store and they can be kept on our desk, bags, vehicles and can also be available in different facilities we frequent. Alcohol based hand sanitizers are effective in destruction of viruses, bacteria and other pathogens. But it leaves questions such as; which hand sanitizer is the most effective? Is hand sanitizer better than Alcohol based hand sanitizer? Basically, there are two major products namely; Alcohol-based gels and Alcohol-free foaming hand sanitizers. They both have benefits and drawbacks. Alcohol based hand sanitizers are rubbed on the palm and they are thereafter absorbed by the skin. The skin made up of three layers namely; superficial epidermis, dermis and hypodermis. The skin no doubt has its own defence mechanism as it protects against invasion of microbial agents [31]. Studies have shown that long term usage antibiotics, hand sanitizers and hand washing disrupt distribution of skin flora [32]. The even distribution and micro-biota balance is important to reduce virulence [33]. Naturally there is skin regeneration which takes about twenty eight days starting from the mitotic division of basal epithelium to desquamation [34]. When the dead keratinocytes in the skin are removed, it takes away the microbes that colonized the skin surface. This continuous process significantly limits the invasion of bacteria while achieving a balanced growth among the microbial populations [35,36]. The Coronavirus has a unique genome sequence that is similar to Severe Acute Respiratory Syndrome as they share almost same morphology since they belong to the same genus Beta Coronavirus [37]. They are positive single stranded RNA viruses. The good news is that, these viruses can be removed, deactivated or rendered redundant by solvent (Lipid in nature) such as propanol, isopropanol and ethanol. Their growth can also be inhibited by certain disinfectants, chloroform and antiseptics [38,39]. Concentrates of about 60%–80%, is a potent agent effective against lipophilic viruses and hydrophilic viruses [40]. The recommended level of ethanol in hand sanitizers according to World Health Organization is 80%, for isopropanol 75% while Propanol is 70%. However, studies have shown that 60%–80% of ethanol is effective against viruses while the same cannot be said about propanol and isopropanol on the same scale respectively [41,42]. A study conducted with WHO showed a demonstration of the effectiveness of alcohol as a strong viricidal against emerging pathogens such as Ebola Virus, Zika Virus, SARS-CoV, and MERS-CoV [43]. Another study conducted in Germany found that the ethanol in the concentration of 42.6% was able to destroy SARS coronavirus and MERS coronavirus hence we can conclude that the effectiveness of alcohol based hand sanitizers varies based on concentration levels [44]. Detergents has the ability to wash off microbes while alcohol based hand sanitizers has the ability to destroy micro-organisms; any agents that is not killed in the process by the use of alcohol based hand sanitizers can be washed away using soap and water. They have similar properties though different molecules. The FDA recommends that hand sanitizers should contain 60%–95% alcohol for maximum protection against germs. Albeit, Alcohol based hand sanitizers are recommended by leading health organizations (National & International) such as NCDC, WHO and FDA, NAFDAC etc. Alcohol based hand sanitizers are by far the most widely used sanitizers in Hospitals and other health care facilities. Its effectiveness has been proven time and time again, withstanding the test of time.

Adverse effects

There is little adverse effect of alcohol based hand sanitizers and they are identified as follows;

- Temporal effect on Microbes
- Weak action against Some microbes (Non-lipophilic virus, bacterial spores and protozoa)
- Flammability
- Skin Toxicity

Alcohol based hand sanitizers are known to be highly flammable due to alcohol concentrates and as such can be dangerous when carelessly used near fire source [45]. There were reported cases of skin burn sustained due to use of alcohol based hand sanitizers. The victims were said to have handled cooking immediately after applying Alcohol based hand sanitizer while the moist was still very much on the surface of the skin. It is advisable to stay away from fire source after application of Alcohol based hand sanitizers at least until the skin surface is dry. Alcohol based hand sanitizers are not effective against non-lipophilic virus, bacteria spores and protozoa hence those who do not have this knowledge would assume they are safe when dealing with virus that are non-lipophilic after using alcohol based hand sanitizers [46]. It should be noted that alcohol based hand sanitizers is effective against Coronaviruses as they are lipophilic viruses. There can also be case of skin toxicity due to high concentration of alcohol above the recommended limit [47]. Since there are various brands of alcohol based hand sanitizers proliferated in markets without regulation, there are risk of sale and use of products that could cause skin toxicity due to potent level of alcohol. It is advisable to select products with less irritating agents and moisturizing skin after hand hygiene and avoiding habits that may cause or aggravate skin irritation. Health workers can also use products that are effective, safe and compatible with all skin types [48]. To reduce or forestall the problems listed above alcohol based hand sanitizers containing humectants or emollients can be utilised [49]. There are researches and studies on the use of Benzethonium Chloride which broadens the effectiveness against viruses and at the same addresses the adverse effect on skin as it tackles concerns about flammability associated with alcohol based hand sanitizers [50]. However, it should be noted that standard hand washing practice is preferable and more effective if the hands are visibly dirty, greasy or contaminated as the hand surface coverage when alcohol based hand sanitizers are used stands at 20-30seconds hence the coverage is limited [51]. Alcohol based hand sanitizers contains ethanol and isopropanol and they are both effective in killing germs and viruses however high concentration of ethanol in alcohol based hand sanitizers is of major concern in Nigeria. The installation of alcohol based dispensers in hospitals and health centres has to resort to consulting with local fire-fighting services due to their level of flammability. More worrisome is the potential toxicity when ingested accidentally or incidentally. Since they can be easily opened, it should be kept out of the reach of children as its high level of consumption can lead to acute alcohol poisoning. Another possible side effect of prolonged use of alcohol based hand sanitizers is the dryness and cracking of skin (Palm). Alcohol has the ability to remove oil on skin surfaces and reduces its ability to retain moist hence the temporary loss of these moist and oils can lead to symptoms of dermatitis. Alcohol based hand sanitizers can also stain areas where sanitizer dispensers may leak or drip.

Alcohol based hand sanitizers are effective against lipophilic viruses which means they are effective against coronaviruses [52-54]. To ensure efficacy of the product, the recommended ethanol concentrates should be strictly adhered to and regulated [56-58]. Alcohol based hand sanitizers has few adverse effects ranging from skin toxicity when ethanol concentrates is relatively high and not regulated courtesy of proliferation of fake products in the market [59-62]. They are known to be flammable in nature and can cause skin burn if they safety and precautionary instructions are not strictly adhered to. Hand hygiene and the use of alcohol based hand sanitizers are effective in preventing direct and indirect spread of COVID-19 [63-65]. The number of n-COV virus is removed on contaminated hand surface. Hand hygiene should be routinely done by health care workers before and after handling of devices, health care instruments and medical appliances; before and after contact with patients; exposure to bodily fluids or secretions of patients; before and after any health care services [66-70]. While individuals should practice hand hygiene after getting home from a public transport; after return from the market;

after contact with surfaces; after handling of appliances and instruments in the church, mosques, schools etc. Hand washing with preparations containing anti-microbial agents can mechanically remove the microbial agents [71-74].

Conclusion and Recommendations

The Nigeria Centre for Disease and Control recommended hand washing with soap and water as it reduces the amount of germs and chemicals on hand surfaces but in cases where water and soap is not available, alcohol based hand sanitizers with concentration of minimum of 60% and maximum of 80% ethanol is effective in preventing COVID-19.

- Recommendations were made to the public on the safe use of alcohol based hand sanitizers while the Government and Health institutions were encouraged to produce standard/low cost hand sanitizers in the fight against this pandemic.
- Appropriate hand washing habit using soap and water is also effective in situations where Alcohol based hand sanitizer is not affordable or accessible.
- Selection of standard Alcohol based hand sanitizers with recommended concentrate of ethanol..

Conflict of Interest

The authors have no conflicts of interest to declare.

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How to cite this article: Oluwatuyi, Shegun Victor, Agbele Tolulope Alaba, Ogunrinde ME, Ayo-Awe Tolulope Veronica, et al. "Alcohol-Based Hand Sanitizers: A Systematic Review on Effectiveness and Effects". *Int J Pub Health Safety* 5 (2020)