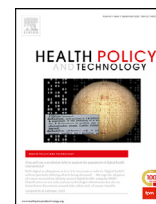




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Original Article/Research

Fast deployment of COVID-19 disinfectant from common ethanol of gas stations in Brazil

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ABSTRACT

Objectives: Coronavirus COVID-19 is spreading very fast in Brazil, requiring innovative strategies for the fast deployment of disinfectants. Panic in population triggered by COVID-19 has caused a shortage of alcohol-based hand sanitizers and disinfectants in many cities of Brazil. Despite the governmental reaction against the outbreak, a risk of shortage of disinfectants still exists. The objective of this research is to investigate an alternative method for the fast deployment of alcohol-based disinfectants to protect the population against COVID-19.

Methods and results: This research highlights the feasibility of disinfectant production from common ethanol available in Brazilian gas stations, as a last resort. A four-by-one (4:1) ratio of common alcohol diluted in water meets the minimum requirements set by health agencies for the alcoholic concentration of disinfectants. Risks factors on alcohol dilution process are associated with corresponding measures of risk mitigation for public health and safety.

Conclusions and perspectives: This research proposes a process for the production and deployment of ethanol-based disinfectant from gas stations. However, the implementation is not timely possible for the COVID-19 pandemic due to complexities in the productive process. For the post-COVID-19 period, the authors give three perspectives: (a) future investigation of human dermal toxicity of common ethanol, (b) establishment of a program for the ethanol decontamination, and (c) countries such as the US, Sweden, Thailand, and Colombia to rethink their energy policy for the adoption of biofuel E100 (ethanol and water) instead of E85 (blend of ethanol, gasoline, and water), as part of their biodefense strategy.

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Introduction

The first steps to contain the outbreak of COVID-19 in Brazil started during the first semester of 2020. Many health organizations instruct the public to wash hands with soap and water or making use of hand sanitizers with alcohol content [1–4]. Alcohol-based hand sanitizers are helpful in reducing the frequency of illness [5,6]. However, a panic of the public due to the coronavirus outbreak, reported in the news, caused a shortage of alcohol-based hand sanitizers in Brazil. The COVID-19 outbreak is spreading globally, including Latin America [7–9].

The author of this paper takes an out-of-box perspective of the COVID-19 pandemic by proposing a process for the shortage of

alcohol-based disinfectants in Brazil as last resort solution for the scarcity of COVID-19 disinfectants, presenting the timeline of facts of regulatory agency decisions concerning alcohol in parallel with the fast speed of COVID-19 outbreak in Brazil, and define health and safety policy for alcohol-based disinfectant deployment as a last resort.

A brief overview of the infrastructure for ethanol-fuel distribution in Brazil

In 1975, the Brazilian federal government introduced the National Alcohol Program (Proalcool) to increment the consumption of ethanol by mixing it with gasoline to propel common gasoline vehicles [10,11].

In the period of 1979 to 1985, during the second oil shock, the Proalcool program incentivized the construction of alcohol distilleries. The automotive sector, at the same time, focused on the manufacturing of cars powered exclusively by ethanol [12].

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Table 1
Comparison between Common Ethanol, Additive Ethanol, E85.

Usual name	Common Ethanol (E100)	Hydrous Ethanol with additive	Anhydrous alcohol with gasoline
Synonyms	Ethyl Alcohol without additive, or Reference Hydrous Ethanol	Ethyl Alcohol with additive	Ethyl Alcohol with gasoline (E85)
Chemical Composition	Ethyl Alcohol (92.6 – 93.8% min. 94.6% max) Water (remaining) Gasoline trace (30 mL/L max.)	Ethanol (92.6 – 93.8%) Water (6.2 – 7.4%) Additive (0.03–0.06% m)	Anhydrous alcohol (85%) Gasoline (15%)
COVID-19 disinfection application	Under consideration in this research	Not appropriate for COVID-19 disinfection due to harmful additive	Not appropriate for COVID-19 disinfection due to high content of gasoline
Carcinogenicity	Not expected in the product	Additive (category 2)	Not considered carcinogenic for humans, according to the International Agency for Research on Cancer. (IARC).
Material Safety Data Sheet	[14,15]	[16]	[17]

In 2018, the total production of ethanol was 33.1 million of cubic meters, being 23.7 million of hydrous ethanol [13]. Decades of experience in the production, storage, and distribution of ethanol for vehicles have also led to a currently vast and well-established infrastructure of gas stations throughout Brazilian territory [13]. In 2018, the total number of gas stations in Brazil was 40,021 [13]. Most of the gas stations in Brazil are currently equipped with fuel dispensers to pump ethanol fuel into vehicles [13].

Despite the vast availability of ethanol in gas stations in Brazil, only one type of ethanol-based product has a potential for the production of COVID-19 disinfectant.

Table 1 summarizes ethanol-based fuels commercialized in Brazil and specifications according to material safety data sheets [14–17].

Common ethanol shows potential for use as COVID-19 disinfectant due to the absence of additive and gasoline. However, the concentration of ethyl alcohol is above 92.6%. This concentration is not usual in the common practice of disinfection in the technical literature [18,19]. An adjustment of concentration would turn common ethanol into a regular and effective disinfectant to COVID-19.

The infrastructure for ethanol distribution in other countries of the world

The three largest ethanol-producing countries are the US (56%), Brazil (28%), and the European Union (5%) [20].

Most of the ethanol refineries in the US are in the Mid-West region [20]. The US has around 4,500 gas stations offering E85 and other flex fuels [20]. The American flex vehicle runs with a seasonal-dependent blend of ethanol and gasoline [20]. Gas stations pump two types of mixture: E85 Summer (74% ethanol and 26% gasoline) and E85 Winter (82% of ethanol and 18% gasoline) [21]. E85, despite the existing distribution infrastructure, cannot be used as a disinfectant.

In Europe, Sweden is the leading country in the ethanol-fuel consumption with 1,695 gas stations for E85 [22]. Ethanol fuel E85 (approximately 85% ethanol and 15% gasoline) and E70 Winter (70% of ethanol and 30% gasoline) are commercially available [23]. Ethanol fuel ED95 (approximately 84.36% ethanol, 4.44% water, and 11.20% additive) are used in trucks and buses in Sweden [22,24]. An alternative ethanol fuel called 5%GE (approximately 89.3% ethanol, 4.75% water, 0.95% Lauric acid, and 5% Glycerol ethoxylate) is being investigated in the technical literature [24]. Due to the presence of gasoline or additive, despite the existing infrastructure of gas stations in Sweden, E85 and ED95 fuel cannot be used as a disinfectant.

India, Thailand, Colombia, Mexico, Australia, and Guatemala cultivates approximately 32% of the world's sugarcane crop, a raw material for ethanol and sugar production.

In India, despite the great potential for ethanol production, a huge demand by its internal market make unfeasible, in the short term (2020), the blending of ethanol in the gasoline for concentration above E50 [25]. During the COVID-19 pandemic, India implemented repurposing of the existing industrial capacity of private liquor companies for the production of ethanol-based sanitizers. However, such repurposing was unlikely quick enough because the supply chains become affected in the pandemic [26,27]. Similarly, repurposing of breweries for ethanol-based sanitizers has proceeded in the US, Canada, European Union, and the United Kingdom [28].

Thailand is expanding the utilization of ethanol fuel E85 for transportation [29]. Colombia is planning to introduce E85 in its markets in 2030 [30,31].

The literature review shows that some countries, such as the US, Sweden, Thailand, and Colombia, have the infrastructure and plans for the production and distribution of ethanol fuel E85. One of the significant barriers for E100 distribution infrastructure was that a flex-vehicle required a small independent tank for the injection of gasoline into the motor engine during the start of a vehicle on E100 [32]. A new technology of injectors provides preheating of the E100 for the cold start of the vehicle, allowing start without gasoline injection system [32]. Such new technology opens new opportunities for the widespread adoption of ethanol fuel E100 in these countries.

Method for adjustment of ethanol concentration for usage as COVID-19 disinfectant

Health agencies around the world diverge on the minimum ethyl alcohol concentration. Brazilian Federal Ministry of Health recommends the same as the World Health Organization, i.e., 70% concentration of ethyl alcohol [4].

Table 2 presents different minimum ethyl alcohol concentrations recommended by health agencies.

Assuming that the alcohol-based disinfectant must meet the requirements of the Brazilian Federal Ministry of Health, the process of disinfectant production must result in a possible 70% of alcohol concentration [4].

This percentage number suggests that the ratio of 4:1 would closely meet the recommendations of the Brazilian Federal Ministry of Health, leading to a concentration calculation of:

$$\text{Concentration}_{(4:1 \text{ dilution})} = 4 \times 0.926/5 = 74.1\% \quad (1)$$

Table 2
Different recommendations of health agencies for alcohol concentration.

Health Agencies	Recommendations in March 2020	Recommendations after March 2020
Centers for Disease Control and Prevention (CDC)	Minimum 60% ethanol or minimum 70% isopropanol [3]	hand sanitizers with 60% to 95% alcohol [33]
World Health Organization (WHO)	At least 60% alcohol-based hand sanitizers, or 70% for small objects [1,2]	After May 15, 2020, proceed surface cleaning followed by 70% - 90% ethanol [34]
Brazilian Federal Ministry of Health	It may (not must) be 70% alcohol concentration [4]	It may (not must) be 70% alcohol concentration [4]
Brazilian Federal Counsel of Chemistry	minimum 60% and a maximum 80% are also effective, according to some studies. [35]	minimum 60% and a maximum 80% are also effective, according to some studies. [35]
ANVISA	It is illegal commercialization of liquid ethyl alcohol one-liter bottle for the public in supermarkets and drug stores if the concentration is above 54%, except for 70%[36].	It is illegal commercialization of liquid ethyl alcohol one-liter bottle for the public in supermarkets and drug stores if the concentration is above 54%, except for 70% [36]. After May 26, 2020, proceed cleaning with 70% alcohol or neutral detergent cleaning, followed by 60% to 90% alcohol [37].

According to the material safety data sheet (MSDS) of the common ethanol, there is a tolerance of 92.6% to 94.6% in the composition of ethyl alcohol in the common ethanol product [14,15].

The common ethanol can reach up to 94.6% maximum concentration due to tolerance of the productive process. In this case, the dilution process would result in 75.68% maximum concentration, assuming the evaporation of ethyl alcohol negligible in the dilution process.

Results and risks

The resulting concentration of the 4:1 dilution process is 74.1%. For ANVISA, commercialization of 74.1% ethanol for the public is illegal because it exceeds 70% [36]. However, 74.1% ethanol concentration is within the 60% - 90% range, also recommended by ANVISA for surface cleaning [37]. The 74.1% ethanol concentration is also within the 60% to 80% effective range of the Brazilian Federal Council of Chemistry [35]. It is also close to 78.2% and 80% ethanol concentration for disinfection reported in the technical literature [5,18,19]. In June 2020, a literature review shows that SARS-CoV-2 is efficiently inactivated by ethanol concentrations ranging from 60% to 95% (v/v) or from 70% and 91.3% (v/v) [38]. SARS-CoV-2, the pathogen of COVID-19 pandemic, is not a bacteria. Concentrations not exceeding 80% for high contact time necessary to achieve an efficient bactericidal activity are disregarded by the Federal Drugs Administration [38].

The 4:1 dilution of common ethanol in water for COVID-19 disinfection brings some risks for the population

The handling of common ethanol by non-qualified public brings risks to their health and safety. Table 3 indicates some of them.

A perspective for health and safety policy should include the mitigation of these risks because it is part of the strategy of pandemic fatalities minimization. However, the implementation of clinical trials for dermal toxicity and a perspective formulation of a health and safety policy for alcohol-based disinfectants is under the constraint of time, since the COVID-19 pandemic continues to spread at fast speed. A timeline of facts gives the context of challenges during a pandemic.

The timeline of facts concerning COVID-19 and regulatory agencies in Brazil

ANVISA, the Brazilian federal agency for health surveillance, is in charge of decisions concerning public health in Brazil.

In March 17, 2020, ANVISA issued the Resolution 347, allowing compounding pharmacies to prepare and commercialize six types of alcohol-based products: (a) ethyl alcohol 70% in 50 ml bottles for non-institutional customer, (b) glycerinated ethyl alcohol 80% in 50 ml bottles for non-institutional customer, (c) gel alcohol, (d) glycerinated isopropyl alcohol 75% in 50 ml bottles for non-institutional customer, (e) hydrogen peroxide in 10 vol, and (f) chlorhexidine digluconate 0.5% [41].

On March 17, 2020, the total number of COVID-19 cases confirmed in Brazil was 234 [42].

Despite helping to improve the supply of COVID-19 disinfectants and antiseptics, it is questionable if such measures are too late and too short against the fast COVID-19 outbreak. The compound pharmacies in Brazil, after the ANVISA resolution, still have to start up the production process to make 70% alcohol available to the customers. The progression of the COVID-19 outbreak over time is a constraint to the success of all levels of public governance to minimize the impact on the health system. Some aspects of the ANVISA resolution 347 [41], particularly to the ethyl alcohol 70% in 50 ml bottles, seem in harsh contrast to products available in online sales in the US.

Table 4 shows the differences in bottle volume.

ANVISA established the prohibition of liquid alcohol with more than 54% concentration for sale to non-institutional customers in 2002. The ban on liquid alcohol resulted in a sharp decrease of 60% in the occurrence of burnings caused by flammable ethanol [43]. However, the supply of alcohol for the public seems to be at the highest priority during a pandemic.

On March 21, 2020, the ANVISA resolution gave 180 days of permission for commercialization of 70% liquid ethanol produced by industries in bottles of one liter [36]. Even with the recently approved regulation, a delay is expected from the beginning of the alcohol production process to the actual availability of bottles in the supermarket shelves. In a race against time, the number of confirmed cases of COVID-19 in Brazil on March 21 reached 904 [44].

On April 23, and May 26, 2020, ANVISA published alternatives for ethanol-based disinfectants [37,45]. Table 5 summarizes the ANVISA recommendations for disinfectants of surfaces and objects

Table 3

Health and safety risks of common alcohol handling to the public.

Risk classification	Description	Effect	Mitigation of risk
Health	Public buying inappropriate type of ethanol, for example, ethanol with additive or with gasoline	Inhalation of additive or gasoline	Adequate training of gas station personnel to make the consumer buy the appropriate product (common ethanol).
Health	Inadequate handling of common ethanol during pumping or dilution	Inhalation of alcohol	Adequate training of gas station personnel to pump common ethanol in certified fuel canister and leaving space in it for water addition for alcohol dilution.
Health	Possibility of the presence of a maximum 0.5% of methanol in the common ethanol composition, even though officially prohibited by the Brazilian Petroleum Agency [39]	Skin irritation	Clinical trials for dermal toxicity are needed.
Safety	Blending of common ethanol in unsafe ventilation conditions	Explosion or fire during the dilution process of a flammable material	Water filling prior to the pumping of common ethanol to the certified can.
Safety	Over usage of alcohol-based disinfectant on large areas [40]	Formation of an explosive atmosphere classified area [14].	Adequate instruction to the public not to spread the disinfectant on a large scale in poorly ventilated areas.

Table 4

Alcohol sale advertised to the public in the US, in March 2020.

Online sale	Product	Bottle volume
Amazon.com (USA)	Laboratory-Grade Denatured Ethyl Alcohol, 95%, 500 mL - The Curated Chemical Collection - Not for Use on Body or Skin	500 ml
Amazon.com (USA)	Laboratory-Grade Denatured Ethyl Alcohol, 95%, 1 L - The Curated Chemical Collection	1000 ml
Amazon.com (USA)	Amazon Brand - Solimo 70% Ethyl Rubbing Alcohol First Aid Antiseptic, 16 Fluid Ounces (Pack of 12)	473 ml
Amazon.com (USA)	Denatured Alcohol 200–1 Gallon (128 oz.)	3,785 ml

Table 5

ANVISA recommendations for the disinfection of surfaces and objects.

April 23, 2020 [45]	May 26, 2020 [37]
Ethanol 70%	Neutral detergent cleaning followed by alcohol: 60% to 90% in water solution v/v
Sodium hypochlorite at 0.5%	Neutral detergent cleaning followed by inorganic active chlorine-releasing compounds (e.g., sodium, calcium and lithium hypochlorites): 0.02% to 1.0%;
Bleaches containing hypochlorite (sodium, calcium) at 2–3.9%	Neutral detergent cleaning followed by inorganic active chlorine-releasing compounds (e.g., sodium, calcium and lithium hypochlorites): 0.02% to 1.0%;
Iodinepovidone (1%)	–
Hydrogen peroxide 0.5%	–
Peracetic acid 0.5%	Neutral detergent cleaning followed by peracetic acid: 0.5% (note: can be used in combination with hydrogen peroxide);
Quaternary ammonium, e.g. Benzalkonium Chloride 0.05%	Neutral detergent cleaning followed by quaternary ammonium: from 1000 to 5000 ppm;
Phenolic compounds	–
Disinfectants commonly used with virucidal action.	–
–	Neutral detergent cleaning followed by organic active chlorine-releasing compounds (e.g. dichloroisocyanuric acids - DCCA and trichloroisocyanuric - TCCA: 1.9% to 6.0%;
–	Neutral detergent cleaning followed by potassium monopersulfate: 1%;
–	Glucoprotamine: 0.5 to 1%;
–	Polymeric biguanide (PHMB): as recommended by the manufacturer.

for COVID-19. ANVISA informed that the virus is inactivated by alcohol 70% and chlorine [37].

On April 23, 2020, Brazil reported 43,079 confirmed cases and 2,741 deaths by COVID-19; on May 26, 2020, 363,211 confirmed cases and 22,666 deaths [46,47].

On May 19, 2020, the Brazilian National Oil Regulatory Agency published a technical note not recommending the use of common ethanol from gas stations as COVID-19 disinfectant due to the risk of contamination by toxic products, such as methanol, gasoline, diesel during the production, transportation, and storage process.

Additionally, the common ethanol may have traces of organic salts based on sulfur, iron, sodium, and potassium, whose ingestion or contact with skin and mucous membranes is harmful to health [48].

On May 19, 2020, Brazil reported 241,080 confirmed cases and 16,118 deaths by COVID-19 [49].

Discussions

Soap and water cleaning is a recurrent recommendation in the health organization guidelines [1–4].

However, not all people in the world has an abundant supply of clean water, paper towel, and washing stations. People living in precarious shelters (slums) may not have adequate sanitary installations. Sharing cloth towels can facilitate virus spreading. Washing stations with automatic water faucet and motorized dispensers for contactless paper towel release are not commonplace in the developing countries. Soap cleaning may require scrub sponge for rinsing and rubbing, gloves for hand protection, and more paper for drying. Water spillover during the cleaning may cause mold proliferation.

On the other hand, ethanol spares water, sponge, and a large quantity of paper towel supply because it mostly self-dissipate from the surface by volatility and evaporation. It may not be just a matter of convenience but the only practical solution for the most impoverished strata of the society. Also, ethanol from gas stations is available in an outdoor environment, as opposed to soap, sponge, gloves, and paper towels, which usually are in indoor sales point, exposing consumers to community spread of COVID-19.

The COVID-19 pandemic caused an extra peak demand for all types of personal protective equipment and cleaning products [26]. Panic about the unknown life threat caused widespread hoarding disorder. The consumer may not have a choice between soap and accessories (water, sponge, paper towel) or ethanol-based disinfectant since all types of cleaning products become scarce in the sales points during a pandemic. This research aims at an alternative method for peak extra-supply of ethanol-based disinfectant.

The last resort strategy happens when it is better to choose a non-perfect but acceptable alternative than doing nothing. An example of last resort strategy is exemplified by the CDC decision for optimization of supply of facemasks for health care professionals (HCP) under crisis management [26]. Unavailability of facemasks urges CDC to recommend HCP to use homemade masks (e.g., bandana, scarf) for the care of patients with COVID-19 as a last resort [50].

The COVID-19 pandemic caused a fast shortage of personal protective equipment [26,51]. The disinfectant supply suffered the same shortcomings. However, the ethanol fuel E100 currently has risks of toxic contaminants, according to the Brazilian National Oil Regulatory Agency [48].

The risk of toxic methanol in the common ethanol composition is easily eliminated by thorough quality auditing on gas stations by the Brazilian Oil Regulatory Agency, and proper punishment for violation of conformity. The Brazilian Oil Regulatory Agency prohibits the addition of methanol on fuel since 2018 [39]. The assessment of compliance of ethanol fuel in gas stations is monthly reported by the Brazilian Oil Regulatory Agency [52]. Very few cases of methanol in E100 fuel were reported in recent months. In May 2020, for instance, just one non-conformity related to methanol content exceeding 0.5% was detected out of 1,558 samples from different gas stations in Brazil [52]. The elimination of other contaminants, described by Talita and colleagues in [21], may require major intervention on the production process, which would not be timely possible in this COVID-19 pandemic. In the US, the Federal Drug Administration issued on June 1, 2020, an updated temporary policy defining interim impurity limits for fuel-grade ethanol for fabrication of hand sanitizers during the public health emergency (COVID-19) [53].

Conclusion and perspectives

The author of this paper proposes a process for the production of 74.1% alcohol-based disinfectant obtained by a 4:1 ratio dilution of common ethanol of gas stations in Brazil in water. However, the proposal is not timely possible due to the complexities of the ethanol production, transportation, and storage process. It seems

unfeasible in a short period to eliminate all risks of toxicity from contaminants pointed out by the Brazilian Oil Regulatory Agency.

For this reason, three relevant perspective recommendations emerge from the post-COVID-19 period.

Firstly, the scientific community is urged to investigate the human toxicity potential by dermal exposure to the ethanol fuel E100 from gas stations. The National Regulatory Oil Agency are urged to investigate the risks, challenges, and the economic feasibility of improving the quality of ethanol fuel E100 within the parameters of acceptable dermal toxicity.

Secondly, the fast deployment of ethanol-based disinfectants from gas stations may be one course of action of a national biodefense strategy against pandemics and biological attacks. A program for decontamination of ethanol E100, if proved technically and economically feasible, should involve the participation of the health regulatory agency, and the oil regulatory agency, in the context of a national biodefense strategy.

Finally, the perspective of future pandemics like COVID-19 or biological war can make other governments in the world to rethink about ethanol fuel E100 as a new standard for dual-use fuel, instead of E85. Countries like the US, Sweden, Thailand, and possibly in Colombia, major ethanol consumers or producers, may improve their biodefense strategy by adopting the ethanol E100 as their biofuel standard.

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Competing interests

None declared.

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