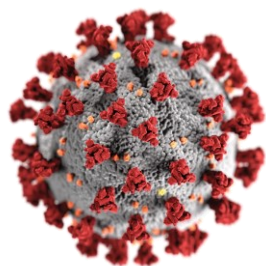




University of Baghdad  
College of Pharmacy



# Toxicological Aspects of Increased Exposure to Disinfectants During the COVID-19 Pandemic

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Sunday, April 17, 2022

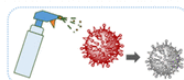


DISINFECT-IT

## Outline

- ▶ COVID-19 pandemic and disinfection
- ▶ Different disinfectants, their mode of action, and exposure
- ▶ Potential impacts to human health
- ▶ Conclusions

### Antimicrobial Effect



### Environmental Impact

QACs uptake by plants and animals



### Disinfectants

QACs  
Alcohols  
Bleach  
Hydrogen peroxide

### Human Exposure

- ▶ Inhalation
- ▶ Ingestion
- ▶ Dermal Absorption

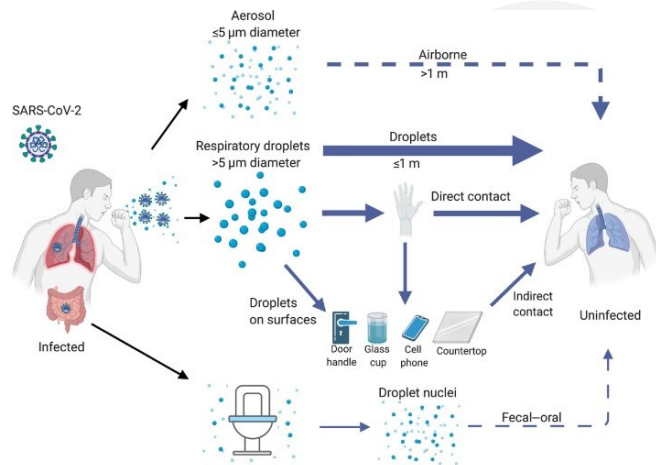
### Potential Impact on Health

Respiratory Damage  
Cardiac Damage

<https://doi.org/10.1021/acs.chas.1c00026>

## COVID-19 Pandemic

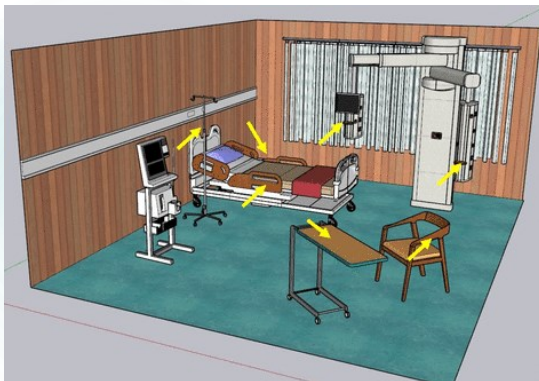
- ▶ Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)
- ▶ Evidence for nonsymptomatic /presymptomatic spread.
- ▶ Enveloped virus → susceptible to disinfectants.



<https://doi.org/10.1016/j.it.2020.10.004>

## COVID-19 Pandemic and Disinfectants

- ▶ Disinfection practices were intensified in private households and public facilities.



### "HIGH-TOUCH" SURFACE SAFETY CLEAN & DISINFECT THOROUGHLY & FREQUENTLY:



<https://doi.org/10.1021/acs.chas.1c00026>

## Disinfection

**A way to kill or deactivate infectious agents outside the body (on inanimate objects).**

### Necessary in areas that are:

- ✓ **Crowded**
- ✓ **Poorly ventilated**
- ✓ **No access to handwashing or hand sanitizer**
- ✓ **Suspected or confirmed COVID 19 patients**

June 12, 2020. MMWR, 69(23);705–709  
<https://doi.org/10.1016/B978-0-12-801773-9.00027-3>

## COVID-19 Disinfection Guidance



<https://blink.ucsd.edu/safety/research-lab/covid-19/decontamination.html>

## COVID-19 Disinfection

**About 1 in 3\* adults** used chemicals or disinfectants unsafely while trying to protect against COVID-19

Stay safe while using household cleaning and disinfectant products



**Always read instructions**



**Wear protective gear**



**Do not mix chemicals**

\*According to a nationally representative survey of 502 U.S. adults—May 4, 2020

CDC.GOV      bit.ly/MMWR6520      MMWR

June 12, 2020. MMWR, 69(23);705–709

## COVID-19 Pandemic and Disinfectants

- ▶ **The U.S. EPA List N: “Disinfectants for Use Against SARS-CoV-2” has 545 products, the major active ingredients include:**
  - ✓ Quaternary ammonium compounds (QACs, quats)
  - ✓ Hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>)
  - ✓ Bleach (sodium hypochlorite)
  - ✓ Alcohols (ethanol and isopropanol)
  - ✓ Acids (peroxyacetic acid)
  - ✓ Phenolic compounds
  - ✓ Others: iodine and glutaraldehyde.

<https://doi.org/10.1016/j.it.2020.10.004>

# List N Tool: COVID-19 Disinfectants

[More Information](#)

[Feedback](#)

# EPA Registration Number	All
Active Ingredient	1,2-Hexanediol
Use Site	Ammonium bicarbonate
Surface Types	Ammonium carbonate
Contact Time	Chlorine dioxide
Browse All	Citric acid
Keyword Search	Dodecylbenzenesulfonic acid
	Ethanol (Ethyl Alcohol) ← <b>In ~ 59 products</b>
	Glutaraldehyde ←
	Glycolic acid
	Hydrochloric acid
	Hydrogen chloride ← <b>in 84 products</b>
	Hydrogen peroxide
	Hypochlorous acid
	Iodine

[Show results](#) [Clear results](#)

Search by selecting one or more option above. Click the "Show Results" button to view your list of results. Select as many options as you wish. Click the "Clear Results" button to remove all selections and start over. Click "Browse All" to display all products.

Total count: 602

# List N Tool: COVID-19 Disinfectants

[More Information](#)

[Feedback](#)

# EPA Registration Number	Hydrogen chloride
Active Ingredient	Hydrogen peroxide
Use Site	Hypochlorous acid
Surface Types	Iodine ←
Contact Time	Isopropanol (Isopropyl Alcohol)
Browse All	L-Lactic Acid
Keyword Search	Octanoic acid
	PHMB
	Peroxyacetic Acid (Peracetic Acid) ← <b>in 31 products</b>
	Peroxyoctanoic acid
	Phenolic ← <b>in 29 products</b>
	Potassium peroxymonosulfate
	Quaternary ammonium ← <b>in 253 products</b>
	Silver
	Silver Ion

[Show results](#) [Clear results](#)

Search by selecting one or more option above. Click the "Show Results" button to view your list of results. Select as many options as you wish. Click the "Clear Results" button to remove all selections and start over. Click "Browse All" to display all products.

## List N Tool: COVID-19 Disinfectants

[More Information](#)
[Feedback](#)

# EPA Registration Number	Phenolic	<b>in 29 products</b>
Active Ingredient	Potassium peroxymonosulfate	
Use Site	Quaternary ammonium	
Surface Types	Silver	
Contact Time	Silver ion	
Browse All	Sodium carbonate	
Keyword Search	Sodium carbonate peroxyhydrate	
	Sodium chloride	
	Sodium chlorite	
	Sodium dichloroisocyanurate	
	Sodium dichloroisocyanurate dihydrate	
	Sodium hypochlorite	<b>in 75 products</b>
	Tetraacetyl ethylenediamine	
	Thymol	
	Triethylene glycol	

[Show results](#)
[Clear results](#)

Search by selecting one or more option above. Click the "Show Results" button to view your list of results. Select as many options as you wish. Click the "Clear Results" button to remove all selections and start over. Click "Browse All" to display all products.

## Properties of Disinfectants

- ▶ Hydrogen peroxide and alcohols are volatile and short-lived.
- ▶ QACs are nonvolatile: adhere to hard surfaces and adsorb onto dust particles more effectively.

## Modes of Action of Disinfectants

- ▶ **Oxidants:** Sodium hypochlorite, povidone-iodine (PVP-I), and hydrogen peroxide .
- ▶ **Nonoxidant agents:** QACs, alcohol, biguanides (chlorhexidine), phenol, and aldehydes (glutaraldehyde).

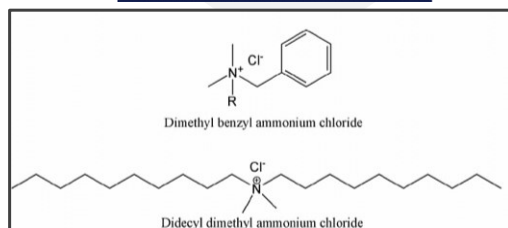
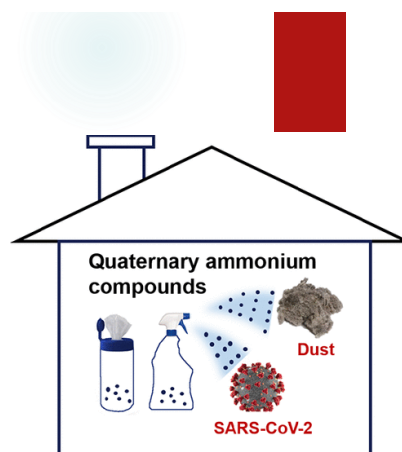
Maliki et al., The Role of Immune System and Sterilization on the Covid-19 Spread Control. Sys Rev Pharm 2021;12(1):579-592.

## QACs

- ✓ Benzalkonium chloride (BAC)
- ✓ Alkyltrimethylammonium chloride (ATMAC)
- ✓ Dialkyldimethylammonium chloride (DDAC)
- Cleaners, fabric softeners, and cosmetics.



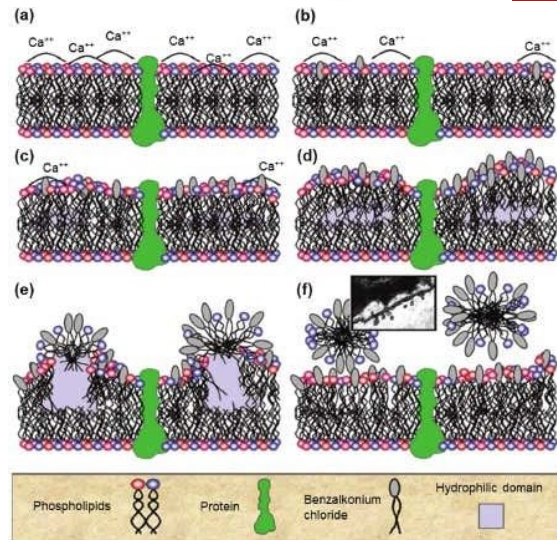
Coco benzyl dimethyl ammonium chloride



<https://dx.doi.org/10.1021/acs.estlett.0c00587>

## Modes of Action of QACs

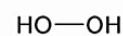
- QACs permeate the phospholipid bilayer of the viruses, causing disorganization of the lipid envelope and deactivate viruses.



<https://doi.org/10.1021/acs.chas.1c00026>

## Modes of Action of H<sub>2</sub>O<sub>2</sub>

- ▶ Attacks intracellular components via the production of hydroxyl free radicals through oxidation, which target sulfhydryl groups and double bonds thereby depolymerizing highly polymerized structures such as nucleic acids and cell membrane.
- ▶ **0.5%, 15 min**
- ▶ **1–6%, 30 s**
- ▶ **Contact surfaces (35% v/v)**



Hydrogen peroxide

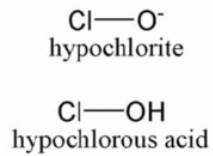


<https://doi.org/10.1021/acs.chas.1c00026>  
<https://doi.org/10.1016/j.coesh.2021.100290>

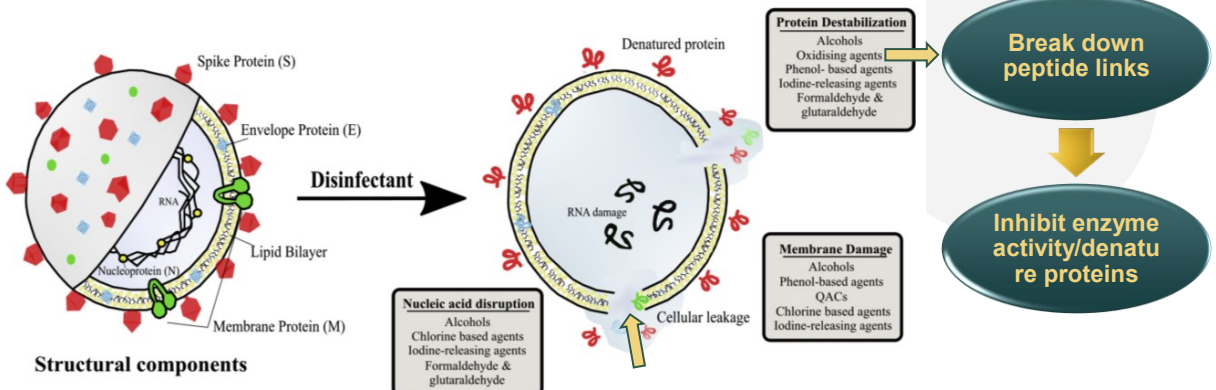


## Bleach

- Widely used (0.1%), with very low cost.



## Modes of Action of Bleach



<https://doi.org/10.1021/acs.chas.1c00026>

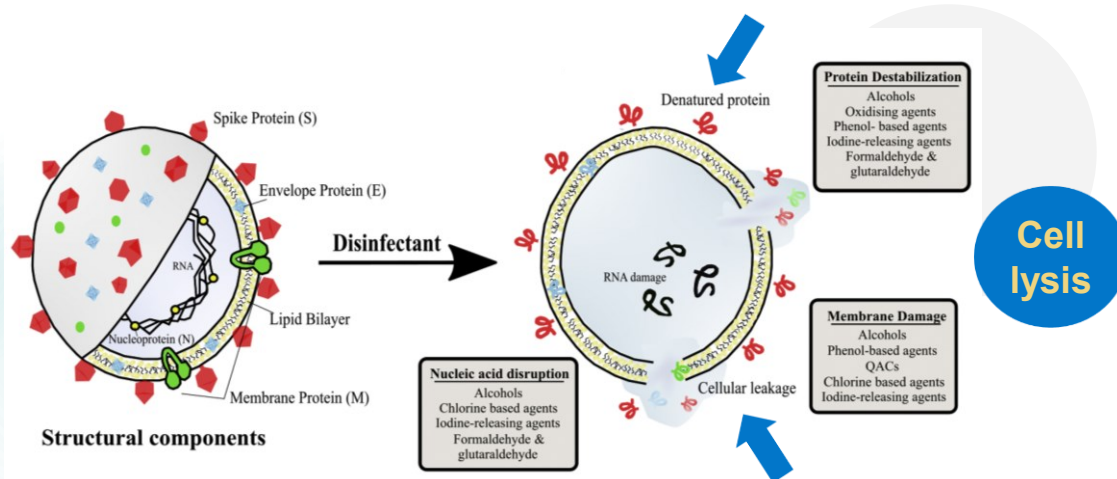
## Modes of Action of Alcohols

- ▶ Widely used in sprays, hand rubs, gels, and foams
- ▶ Hand hygiene (**60-70% v/v, 1 min**), small equipment disinfection, e.g., thermometers, critical tools, non-invasive probes



<https://doi.org/10.1021/acs.chas.1c00026>

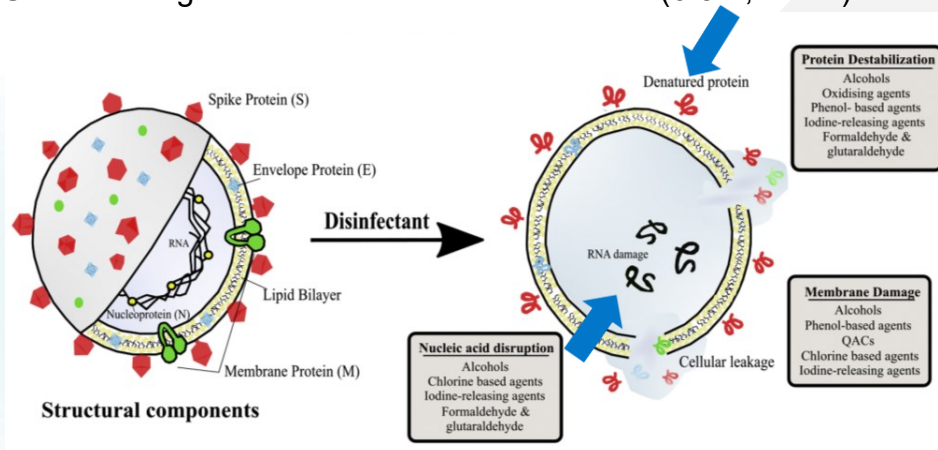
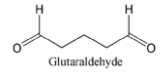
## Modes of Action of Alcohols



<https://doi.org/10.1021/acs.chas.1c00026>

## Modes of Action of Glutaraldehyde

- Used for surgical instruments and other areas (0.5%, 2 min).



<https://doi.org/10.1021/acs.chas.1c00026>

## PVP-I

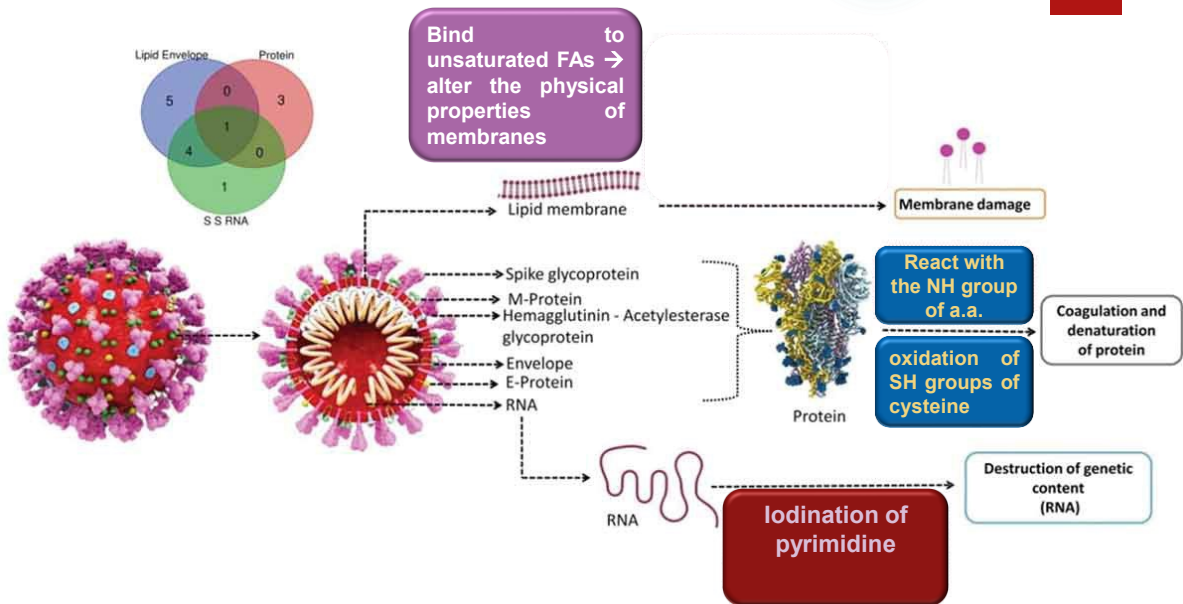
- Widely used iodine complex carried in a polyvinylpyrrolidone carrier.
- **7.5–10%:** Pre-operative skin disinfection, antiseptic hand washes, scrubs, ointments.

—|—  
iodine



<https://doi.org/10.1080/20477724.2020.1807177>  
<https://doi.org/10.1016/j.coesh.2021.100290>

## Modes of Action of PVP-I



## Impact on Human Health

- ▶ Overuse → ↑ exposure to disinfectants via different routes:
  - ✓ Oral
  - ✓ Nasal: aerosolized liquid particles/disinfectant-adsorbed dust particles resuspended in air
  - ✓ Dermal absorption
  - ✓ Ocular
- ▶ Proper uses
- ▶ Accidental exposures due to misuse/improper use

## Adverse Health Effects of QACs

- ▶ Airway allergy , deep lung effects , lung inflammation at higher concentrations, asthma (asthmagens).
- ▶ BAC and DDAC can increase the risk of asthma and COPD.
- ▶ Infertility (studied in mice) at low and ambient concentrations.
- ▶ QACs appears in the blood → ↑ cytokines  
↓ mitochondrial function  
disrupt cholesterol homeostasis

<https://doi.org/10.1021/acs.chas.1c00026>

## Adverse Health Effects of QACs

- ▶ QACs bind to the active site of DHCR7 and inhibit its activity at noncytotoxic concentrations ,cross the BBB in rats.
- ▶ Skin irritation.
- ▶ Disrupt the protective lipid membranes of the skin and increase the absorption of toxic substances.

<https://doi.org/10.1021/acs.chas.1c00026>  
<https://dx.doi.org/10.1021/acs.estlett.0c00587>

## Adverse Health Effects of Bleach

- ▶ **↑** risk of COPD and **↓** asthma control.
- ▶ Indoor bleach cleaning → release of elevated HOCl and Cl<sub>2</sub> to the outdoor atmosphere.

<https://doi.org/10.1021/acs.chas.1c00026>

## Adverse Health Effects of Bleach



- ▶ In combination with other chemicals (e.g., ammonia) → release of chlorine gas, Chloroform, and CCl<sub>4</sub> → severe respiratory health damage.



- ▶ Chlorine in contact with moist tissues → HCl → damage airways, asphyxiation, and death.



<https://doi.org/10.1021/acs.chas.1c00026>

## Adverse Health Effects of H<sub>2</sub>O<sub>2</sub>

- ▶  Risk of COPD and  asthma control.
- ▶ Mild GIT and eye irritations (at 3% or less).
- ▶ Mutagenic effects through DNA and protein damage (at 30%).
- ▶ Life-threatening at concentrations of 75 ppm.

<https://doi.org/10.1021/acs.chas.1c00026>

## Adverse Health Effects of Alcohol Based Disinfectants

- ▶  Risk of COPD and  asthma control.
- ▶ Low risks
- ▶ Large amounts/prolonged exposure is required for systemic toxicity.
- ▶ The reproductive risk is negligibly small
- ▶ Long-term exposure → increased risk of asthma, COPD, and other respiratory issues.

<https://doi.org/10.1021/acs.chas.1c00026>

## Adverse Health Effects of Alcohol Based Disinfectants

- ▶ Skin complications: cutaneous xerosis to irritant contact dermatitis.



<https://doi.org/10.1021/acs.chas.1c00026>

## Adverse Health Effects of Alcohol Based Disinfectants

- ▶ Significant increase in the risk of poisoning, particularly in preschool children, through accidental ingestion of hand sanitizers.
- ▶ Ocular (edema/conjunctivitis), gastrointestinal, CNS effects.
- ▶ Methanol-based hand sanitizers → visual impairment and death.



DOI: 10.2478/aiht-2020-71-3470  
<https://doi.org/10.1080/15563650.2020.1811298>  
 MMWR / August 14, 2020 / Vol. 69 / No. 32



## Recommendations

- PPE , Proper-ventilation.
- The disinfectant and its concentration should be carefully selected.
- Avoid combining disinfectants.
- Hand washing after handling.
- Keep children away during the application and keep the products away from the reach of children.
- Keep lids tightly closed when not in use.
- Warnings informing the general public of the risks of poisoning with surface and hand disinfectants are necessary.
- Supervising children's access to any ABHS is an important public health need

## Conclusions

- ❖ Continuous use and overuse of disinfectants could have short- and long-term adverse effects on human health.
- ❖ Safer handling of these disinfectants is essential to mitigate potential adverse effects.
- ❖ Thorough research on effects of QACs on human fertility, pregnant women, and young children neural development is warranted.

# Thank You and Questions

