Emerging Evidence on COVID-19

Evidence Brief of Potential Health Risks of Hard-Surface Disinfectants in Environments Shared by School-aged Children

Introduction

What evidence exists to inform the potential health risks (contact exposure, inhalation toxicity, poisoning) of increased use of hard-surface disinfectants in environments (e.g. school/ home/ recreation) shared by school-aged children during the COVID-19 pandemic?

Schools are re-opening with more frequent sanitation and hygiene requirements in an effort to mitigate the spread of SARS-CoV-2, the virus that causes the COVID-19 disease, between students and staff. In addition, many public facilities, businesses and homes have adopted enhanced sanitation procedures, which includes increased use of hard-surface disinfectants to reduce the risk of spread of the virus. Hard-surface disinfectants are known to have some associated health risks and their increased use may pose additional health risks to school-aged children.

Hard-surface disinfectants are intended for use as disinfectants on hard, non-porous surfaces and contain active ingredients permitted by Health Canada. Enveloped viruses such as coronaviruses are readily inactivated by many disinfectants (Rai, 2020). A list of approved products (n=526) effective against SARS-CoV-2 is available on Health Canada's website (Health Canada, 2020). Common categories of active ingredients for hard-surface disinfectants include quaternary ammonium compounds, phenolic, idophor, chlorine releasing compounds, and peroxygen (Health Canada, 2015). A general overview of each category is provided in the appendix table. Each of these classes of active ingredients have warnings about the proper use of each chemical.

Disinfectants are regulated as drugs in Canada and although the *Food and Drugs Act* and the Food and Drug Regulations do not specify acute toxicity hazard classification criteria for disinfectant drugs, manufacturers are recommended to consider referencing the Consumer Chemicals and Containers Regulations, 2001 for products intended for non-commercial uses (domestic) by consumers (Canada, 2020a); or Hazardous Products Regulations, 2015 for products intended for use in workplaces or commercial use (Canada, 2020b). When Health Canada approves a disinfectant, precautionary statements to ensure their appropriate use are included on the product labels. These statements describe recommended actions that can be taken to minimize, mitigate and/or prevent adverse reactions from occurring. They are displayed prominently on the labelling of disinfectants to ensure the safe use and handling of the product by the end users in accordance with the label directions. The precautionary statements are relevant to the potential acute toxicity exposure

hazards of the product. In determining the appropriate precautionary statements, Health Canada takes into consideration all the ingredients in the formulation including inert or non-medicinal ingredients. Health Canada ensures that the overall risk benefit of using a product is positive and that potential risks can be mitigated by appropriate labelling.

Contact, inhalation or ingestion of disinfectants can lead to immediate irritation or poisoning. These compounds could cause contact burns or sensitivities to skin and eyes, are harmful if ingested and have inhalation risks during handling and application (CDC, 2020 and Health Canada, 2020). Some disinfectants may leave chemical residues which can become airborne and inhaled; to use safely, these products need to be rinsed off after use. Of particular interest are disinfectant by-products, such as those from chlorine containing compounds like household bleach that may form volatile organic compounds (VOCs) if accidentally mixed with other cleaning products or when it comes into contact with organic matter on a dirty surface (Odabasi, 2014). Some categories of disinfectants have been associated with respiratory issues including asthma due to long term occupational exposure (Appendix table). Measures to address these risks include: using soap and water to clean all visibly dirty surfaces before disinfecting, not mixing disinfectants with other products, opening windows to increase ventilation, wearing gloves when disinfecting, and allowing surfaces to air dry completely before using and staying out of a freshly disinfected area for 20-30 minutes after cleaning (Bello, 2010). Long-term exposure toxicology data is incomplete for many disinfectants, and is generally supported by animal studies. While some have limited adult human data, few have data on children, see the appendix table for a summary for each category of disinfectant.

This review focuses on health risks associated with hard-surface disinfectant use around school-age children both before and during the COVID-19 pandemic. It includes literature published up to October 5, 2020 (Methods are at the end of the document).

Key Points

There is limited evidence on the health risks of hard surface disinfectant use in school-aged children, this review demonstrates that

- Compared with previous years, reports on calls to poison control centres in both the United States (USA) and Canada have documented an increase in calls during the COVID-19 pandemic related to disinfectants and cleaners, with exposures frequently involving children (Table 1).
- People using disinfectants may lack knowledge of their safe use and potential harms based on a consumer survey in the USA (Table 1).
- Studies of children that reside in homes with high disinfectant use have a higher frequency of skin and respiratory effects as well as sensitization to disinfectants (Table 2).

- Some cross-sectional studies have shown an association between the frequency of disinfectant use around children and health effects such as asthma and wheezing in young children (Table 2).
- Chloroform (one of the VOCs that can form when bleach comes into contact with other products or organic matter) has been found at unacceptable concentrations in several early childhood education centres; most of these centres reported using bleach regularly (Table 2).
- Overall, there remains considerable knowledge gaps in the literature on both the short and long term effects that may be experienced by children as a result of the increased use of hard-surface disinfectants.

Overview of the Evidence

Publications that directly report on the potential health risks of increased use of hard-surface disinfectants in environments shared by school-aged children are scarce. We examined not only literature reviews and information about calls to poison control centres during the pandemic (Table 1), but also included available evidence on the health impacts on children from the use of hard-surface disinfectants prior to the COVID-19 pandemic (Table 2). Sixteen relevant publications on exposure to hard-surface disinfectants informed this review. These included epidemiological studies (cohort and cross sectional), reports from poison control, a consumer knowledge survey, risk assessments, literature reviews and commentaries. The overall body of research is very small, of low quality and is insufficient to provide conclusive evidence on the health risks of disinfectant use is school-age children. Additional research in this area is needed.

Excluded from this review were studies that focused on adult or occupational exposure, as well as animal studies, as their exposure levels may differ from school-aged children. General features of disinfectant categories and links to additional information on each category is provided in the appendix table.

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HARD-SURFACE DISINFECTANTS EXPOSURE DURING THE COVID-19 PANDEMIC

Seven studies on the effect of exposure to hard-surface disinfectants in children during the COVID-19 pandemic are summarized in Table 1. This includes two reports from poison control centres, one consumer knowledge survey, one risk assessment, one literature review and two relevant commentaries.

Poison control centres in both the USA and Canada have reported a rise in calls related to disinfectants and general household cleaning products in 2020 compared to previous years (Chang, 2020; Yasseen, 2020). In the Canadian study that tracked calls on cleaners and disinfectants, 42% of calls were related to bleaches and 21% to disinfectants (Yasseen, 2020). The increase was seen in all age groups, but the majority were for adults, not children. In the USA study, bleaches accounted for the largest percentage increase in calls followed by non-alcohol disinfectants. Calls due to exposures among children aged ≤5 years consistently represented a large percentage of total calls from 2018 to 2020 (range = 39.9–47.3%) (Chang, 2020).

A survey conducted in May 2020 found sixty percent of respondents reported cleaning or disinfecting their home more frequently since the pandemic started compared to the preceding months (Gharpure, 2020). It also reported that respondents had limited knowledge of how to safely prepare their cleaning products and disinfectant solutions and 25% of respondents reported experiencing at least one adverse health effect that they believed had resulted from using these products (Gharpure, 2020).

A risk assessment found three-year-old children had the highest potential exposure to disinfected surfaces compared to any other age group due to the higher likelihood of hand contact and mouthing activities (Li, 2020). This risk assessment looked at several chemicals, but not all were hard-surface disinfectants. They also assumed that disinfectants were used at full strength without dilution, the individual was exposed via direct hand contact, and that disinfectants were not wiped off after surface application, which may not be representative of how such disinfectants were actually used by consumers.

Reviews of approved disinfectants which contain quaternary ammonium, sodium hypochlorite or hydrogen peroxide and their use during the COVID-19 pandemic highlight the majority of hard-surface disinfectants used against SARS-CoV-2 (Samara, 2020, Rai, 2020). The literature review identified that residues from some hard-surface disinfectants can contribute to poor air quality, and there is evidence of higher cancer rates attributed to regular use of some of these disinfectants in adults from occupational exposure (Rai, 2020). In some high exposure occupations, studies have shown an association with increased risk of chronic obstructive pulmonary disease, asthma and eye irritation (Rai, 2020; Samara, 2020). Similar data was not identified for children and although 5% percent of childhood cancer and 30% of childhood asthma are related to chemical exposures, the proportion that may be attributed to hard-surface disinfectant use is unknown (Rai, 2020).

Table 1: Studies and reviews on the health risks of hard-surface disinfectants use for school-aged children (n=7)

Study	Method	Key Outcomes
Poison Control Calls		
Chang, 2020 Before/after study USA Jan– Mar 2018, 2019 and 2020	The National Poison Data System calls were analysed for the number of exposures reported for January–March 2020 compared with the same 3-month period in 2018 and 2019.	During January–March 2020, poison centres received 45,550 exposure calls related to cleaners (28,158) and disinfectants (17,392), representing overall increases of 20.4% and 16.4% from 2019 and 2018, respectively. The increase in calls was seen across all age groups but exposures among children aged ≤5 years represented 39.9%–47.3% of calls in the three time periods. Inhalation accounted for the largest percentage increase in calls from 2019 to 2020. The largest increase in calls possibly related to hard-surface disinfectants (2019 vs 2020) were for bleach (62.1%) and non-alcohol disinfectants (36.7%).
Yasseen, 2020 Before/after study Canada Jan – Jun 2019 and 2020	Five Canadian Poison Control Center exposure reports for Jan – June 2020 were compared with the same 6-month period in 2019.	There was a 35% rise in total number of exposures to cleaning products/ disinfectants/ hand sanitizers in 2020 compared to 2019. Of 8187 calls reporting exposures between January and June in 2019 and 2020, those possibly related to hard-surface disinfectants were: 42% for bleach, 21% disinfectants, 12% chlorine gas, and 2% chloramine gas (the latter are bi-products of mixing bleach with other disinfectants or cleaners, see appendix). In the 2020 period, the number of calls peaked in March and generally decreased after April 2020. Exposure calls were predominately among those aged 19+ for both years. The results do not suggest that there was a large increase among those aged <19 years between 2019 and 2020.
Knowledge Survey		
Gharpure, 2020 Opt-in adult internet survey on household cleaning USA May, 2020	The survey included questions to assess knowledge and practices regarding household cleaning and disinfection during the COVID-19 pandemic.	Included 502 adults (18+) 60% reported more frequent home cleaning/ disinfection use compared with preceding months. Limited knowledge of safe preparation of cleaning and disinfectant solutions was reported across several questions. 39% of respondents reported high-risk practices not recommended by CDC including: 1) Applying bleach to food (19%)

		2) Use of household cleaners and disinfectants on hands (18%) 3) Misting the body with cleaners and disinfectants (10%) 4) Inhaling vapors (6%) 5) Drinking or gargling diluted bleach solutions (4%), soapy water (4%), or other cleaner/ disinfectant solutions (4%). 25% reported at least one adverse health effect that they believed resulted from using cleaners or disinfectants. These were more common (33% vs. 25%) in respondents who reported a high risk practice.
Risk Assessment		
Li, 2020 Risk assessment and quantitative exposure model of 22 disinfecting chemicals which have been highlighted to kill SARS-CoV-2 USA and Canada[1] September, 2020[1]	Risk assessment use PROTEX an indoor fate and chemical exposure model. Three exposure routes (mouthing-mediated oral ingestion, inhalation, and dermal absorption) were investigated. The application scenario relevant to this review was disinfection of indoor surfaces and objects (surface application). Three age groups were modelled: 3, 14, and 24 year olds.	<u>Exposure risk assessment</u> Three-year-old children had highest overall exposure, especially to disinfected surfaces, due to higher frequency of hand contact and mouthing activity. Surface disinfectant exposure risk, especially for young children were noted. Mouthing-mediated ingestion dominates the exposure to non-volatile disinfectants whose residues can stay on surfaces until removed by normal cleaning (e.g. quaternary ammonium compounds). For older age groups this exposure was through dermal absorption and was also noted for phenolic chemicals. For disinfectants like triethylene glycol (low toxicity) that are aerosolized to disinfect and clean the air, exposure was mainly due to inhalation. Although this risk assessment looked at 22 chemicals, many were not hard-surface disinfectants.
literature reviews		
Rai, 2020 Literature review Jun 2020	Studies on the potential harmful effect of disinfectants and safe alternatives were summarized in the context of COVID-19.	5% of childhood cancer and 30% of childhood asthma are related to chemical exposures, it is unknown if any of these are attributed to hard-surface disinfectants. The majority of products recommended by the EPA for use against COVID-19 contain the active ingredients from quaternary ammonium compounds (Quats).

		Many of these are linked with an increased risk of chronic obstructive pulmonary disease (COPD), asthma, and eye irritation when used regularly (occupational exposure). Quats have been shown to possibly cause fertility issues in animal studies. When not rinsed properly after use, biodegradable disinfectants will leave an active chemical residue on the surface applied. Disturbance of the residue can cause it to be airborne, which may cause irritation for some people. Thorough rinsing and general cleaning removes the residue.
Commentaries		
Rivera, 2020 Commentary USA[1] Jan – May 2020	Using Google Trends, evaluated search interests for the purchase and consumption of disinfectants and for poison control centres after the USA president implied injecting disinfectants may be a potential treatment for COVID-19. Confidence intervals for each trend were calculated by averaging multiple samples collected daily over a 3-week period.	The relative search fraction (RSF) values from January-February, 2020 for purchasing, drinking, or injecting disinfectants were minimal (<1). A day after Trump's comment, RSF for drinking disinfectants was 32.3 and injecting disinfectants was 100. RSF for poison control centres peaked a day later (RSF=11·05), indicating an increase in interest or possibly for information or assistance following off-label use of disinfectants.
Samara, 2020 Commentary United Arab Emirates[1] 2020[1]	Safety of disinfectants is presented for some of the most widely used natural and synthetic surface disinfectants approved by the Environmental Protection Agency for the prevention of SARS-CoV-2 and reviews associated health effects.	Hard-surface disinfectants can cause irritation of the skin and eyes, irritation to the respiratory tract, and asthma in some individuals. The use of bleach can result in the formation of VOCs in the indoor air, and high concentrations of VOCs are reported 30 minutes after application. This indicates that the use of bleach may be an important source of VOC inhalation exposure. An ideal disinfectant should have a low toxicity profile with short and long term exposure e.g. Quaternary ammonium compounds and peracetic acid: (see appendix table).

[1] The country was based on author location or the date was based on date of publication.

GENERAL EXPOSURE TO HARD-SURFACE DISINFECTANTS

While there are no recent studies on how the increased exposure to hard-surface disinfectants during the pandemic will affect the health and safety of school-aged children, studies conducted prior to the COVID-19 pandemic can provide additional information on the effects of exposure to hard-surface disinfectants among children.

The biologic monitoring study of 34 early childhood education centres in California reported that chloroform, a VOC related to chlorine bleach use, exceeded the acceptable cancer risk levels in 38% of facilities (Hoang, 2016).

Two exposure assessment studies found that bleach is commonly used in daycare centers in the USA. A survey in fourteen childcare facilities in Washington, DC reported on the use of chlorine bleach (92.8%) in their facilities for sanitation purposes and chloroform was detected in all facilities (Quirós-Alcalá, 2016). The most common sanitized surfaces were tables, bathrooms, chairs along with beds, changing tables and children's toys. Bleach has been reported to be an airway irritant if inhaled and can release VOCs (e.g. chloroform) when it reacts with organic material, which is a known carcinogen. The third risk assessment measured and modelled the quantity of VOCs produced during normal indoor cleaning tasks. The results suggest that there is potential for exposure to above-average levels of VOCs to anyone who enters the room up to 20 minutes after cleaning sinks, mirrors, or toilets with disinfectants containing quaternary ammonium compounds or sodium hydroxide (Bello, 2010). Increasing ventilation and decreasing time in a newly cleaned room would reduce exposure to VOCs. Three epidemiologic studies have been published. A prospective cohort study from Germany of youth ages 19-24 showed the use of disinfection products was associated with an increase in asthma and atopic dermatitis. Self-reported exposure to household disinfectants and high use of disinfectants was associated with a two-fold increased odds of asthma incidence compared to those who reported no use (Weinmann, 2017). Youth who reported low or medium use of disinfectants were also more likely to report remittent asthma (Weinmann, 2017). In a cross-sectional study of 4-year olds in several European countries, households with high use of disinfectant room sprays were associated with increased atopic dermatitis and itchy rashes, but not asthma (Krauss-Etschmann, 2009). A weakness of this study was general disinfectant use was not recorded (Krauss-Etschmann, 2009). A cross-sectional study from Sweden found that use of chlorine bleach in the home had a protective association with developing asthma and sensitization to indoor allergens, but did not specify whether children were present during cleaning (Nickmilder, 2007).

Three literature reviews summarized the evidence on the potential risk to children which is mostly cross-sectional studies of cleaning/disinfection products and the VOCs associated with those products (Holm, 2019; Mendell, 2007; Slaughter, 2019). The most common categories of disinfectants reported across studies included bleach, quaternary ammonium compounds and peroxides, chosen for their broader range of disinfection across pathogens (Holme 2019). Indoor cleaning activities were associated with allergies, asthma and other respiratory issues in infants and young children (Mendell, 2017). Most of these studies did not

specify the products being used, and often multiple types of products were used, so separating out the impact of one product over another was not possible.

Table 2: Reports on health risks of hard-surface disinfectants from pre-pandemic literature (n=9)

Study	Method	Key Outcomes
Exposure / Risk Assessments		
Hoang, 2017 Biological monitoring study USA May 2010 - May 2011	38 VOCs were measured in single-day air samples collected in 2010-2011 from 34 ECE facilities serving California children and evaluated "No Significant Risk Levels" (NSRLs) defined as the daily dose posing a one in 100 000 excess risk of cancer over a lifetime.	Chloroform - a VOC associated with the use of chlorine bleach - was identified in some samples. Other VOCs were not associated with hard-surface disinfectants, however they maybe VOCs produced by fragrances that are added to a cleaning or disinfection product. The 95th percentile dose estimates for chloroform exceeded the age-specific NSRL in all four age groups assessed. Findings: VOC levels in ECE facilities resemble those in school and home environments and, if reflective of long-term averages, child dose estimates exceeded age-adjusted NSRL benchmarks for benzene, chloroform, ethylbenzene, and naphthalene in 71%, 38%, 56%, and 97% of facilities, respectively. In bivariate analysis: Levels of VOCs were similar in facilities that reported use/purchase of low-toxicity cleaners compared with those using traditional cleaners. However, some VOCs were significantly higher in facilities with higher mopping frequency, suggesting VOC emissions from floor cleaners.
Bello, 2010 Exposure assessment study USA[1] 2010[1]	Sink, mirror, and toilet bowl cleaning tasks were simulated for 20 minutes in a large ventilated bathroom and a small unventilated bathroom using a general purpose, a glass, and a bathroom cleaner. Airborne total volatile organic compounds generated during the tasks were measured.	The household cleaners used contained Quaternary Ammonium Compound or sodium hydroxide. Exposures above the background level were present for approximately 20 minutes after the tasks ended. The highest concentration of ammonia occurred while mirrors were being cleaned. Results suggest that there is potential exposure to anyone who is cleaning the room or who enters the room shortly after cleaning.
Quirós-Alcalá, 2016	Childcare center directors were initially contacted via email and letters. A	Chloroform (a VOC that may originate from products containing chlorine bleach) was detected in every

Exposure assessment study Washington, DC. Fall of 2012 and 2013	questionnaire was administered to childcare center directors. They also collected information on the number of children with asthma at each facility and whether any children experienced asthma attacks or wheezing episodes in the three months prior. To characterize VOCs within the facilities, they collected between two and five 10-h air samples and real-time particulate matter instrument samples at 1 min intervals.	facility. It is important to note that there may be other sources of chloroform. 92.9% of center respondents stated that chlorine bleach was used for sanitizing in the facility. The most commonly reported surfaces sanitized were tables, bathrooms, and chairs, however, respondents also reported the use of chlorine bleach to sanitize beds, changing tables, and children's toys. The indoor pollutants from using chlorine bleach are known respiratory irritants. The authors recommend looking at bleach-free alternatives for disinfection to avoid introducing other hazards into the childcare setting.
Epidemiological Studies		
Weinmann, 2017 Prospective cohort study Germany 2007-2009	2051 young adults between the ages of 19-24 years living in two major German cities took part in a study to self report their exposure to household sprays and disinfectants. Associations with clean product exposure and asthma or wheezing were investigated.	In this sample 83.8% of respondents did not report using disinfectants. No information on what disinfectants were used were collected. Asthma was reported in 5.4% of the sample: - High use of disinfectants was seen to be associated with two-fold increase odds of asthma compared to those with no use (OR 2.79, 95% CI 1.14 to 6.83). - Low and medium disinfectant use was associated with remittent asthma (OR 2.39, 95% CI 1.29 to 4.47). Wheezing in the last 12 months (not related to cold) 17.1%. There was no clear association between exposures and wheezing identified. No causal inferences can be drawn from this data, additional exposure assessments are warranted.
Krauss-Etschmann, 2009 Cross sectional study of 4 year olds (106 Spanish, 45 German, and 25 Hungarian infants).	Children at the age of 4 years underwent a medical and neurophysiologic examination. During this visit, parents completed a standardized questionnaire, which included questions about allergies and asthma in childhood and lifestyle	No information on room disinfectant used was provided. Use was categorized as daily, weekly, occasional or never. Application of room disinfectants was not associated with higher effect estimates for asthma but significantly increased effect estimates for atopic dermatitis and itchy rash. No data on the type of disinfectant was reported.

Spain, Germany and Hungary 2009[1]	related factors. Descriptive categorical data were analyzed with χ^2 analysis. The likelihood of allergic symptoms in relation to household room spray application was assessed in bivariate analyses.	
Nickmilder, 2007 Cross sectional study Sweden Mar-May 2002	The study evaluated the extent that regular house cleaning products with bleach influence the risk of allergies and respiratory diseases. A group of 234 schoolchildren aged 10–13 years old among whom 78 children were living in a house cleaned with bleach at least once per week. Parents of children were asked to complete a questionnaire that included a total of 38 questions.	Children living in houses regularly cleaned with chlorine bleach: - Lower risk of developing asthma, which was significant if both physician diagnosed and screening test positive children were included in the analysis. - They were less likely to be sensitized to indoor allergens including house dust mites (significant). - They were less likely to report wheezing (not significant).
Literature reviews		
Mendell, 2007 Literature review of epidemiologic studies USA[1] Up to mid 2004	Assessed the association between indoor residential chemical emissions, materials or emission-related activities and respiratory or allergic effects in children and infants.	Types of indoor residential materials and coatings, as well as renovation or cleaning activities, were associated with health effects related to asthma or allergy in infants or children. Use of many chemical-based cleaning products (women used more than one, however 87.4% were disinfectants, 84.8% were bleach) by mothers was measured by questionnaire and total chemical burden (TCB) in one study (Sherrif 2005). High TCB was associated with a significant dose–response increase in persistent wheeze in young children (adjusted OR 2.3 (95% CI 1.2 to 4.4) and late-onset wheeze in young children (adjusted OR 2.0 (95% CI 0.8 to 5.2)). No single product was implicated in children wheezing. These findings could be impacted by numerous confounders and conclusions about a causal relationship cannot be inferred from the studies presented.

Slaughter, 2019 Literature review New Zealand[1] Jan 1950 to Jun 2018	Review of hypochlorite poisoning.	Sodium hypochlorite is used as a bleaching and disinfecting agent and is commonly found in household bleach. 110 citations were deemed relevant. Estimates of greater than 40 mL or 5 mL/kg in children of dilute solutions have been suggested as amounts likely to cause corrosive or systemic poisoning. This review describes multiple case reports/series of children ingesting bleach. Common effects included minor gastrointestinal features, such as nausea, vomiting, and superficial burns in the mouth/esophagus. Brief skin exposure to household bleach normally causes minimal effects. Prolonged or extensive exposure may cause skin irritation or hypersensitivity.
Holm, 2019 Literature review USA[1] 2018[1]	Summarized findings from: (1) Environmental Protection Agency registration data on the efficacy of hospital-grade disinfectants (n= 1907 products, 529 of which were included). (2) A review of the research on the toxicities/health risks of common disinfectants in childcare settings.	Bleach is the most common disinfectant used in childcare settings. A bi-product of bleach is the VOC chloroform. Without optimal ventilation rates, some studies have reported chloroform levels above those considered safe for managing cancer risk. Similar findings were reported for formaldehyde which can be a bi-product of improper mixing of cleaning and disinfectant chemicals. Data on the effects of cleaning products on children are limited. Cross-sectional studies have indicated that homes cleaned with bleach were not more likely to have asthma whereas others have found an increased risk with use of sprays and disinfectants in the home. A relationship between use of cleaning sprays and wheezing has been reported across a couple studies in infants and young children. Classes of disinfectants with at least one product that had wide pathogen coverage included bleach, peroxides, quaternary ammonia compounds, and combination products that included quaternary ammonia compounds. Health Risks: Bleach: airway irritant if inhaled and can release VOCs e.g. chloroform when it reacts with organic material, which is a known carcinogen. Skin and eye irritation is common, poisonings have been reported and long-

		term exposure in adults has resulted in respiratory effects, asthma. Quaternary ammonium compounds: Increased risk of asthma and allergic sensitization has been reported. Some have been shown to be mutagenic and reduce fertility rates in animal models. Carcinogenicity has not been shown. Peroxides: Acute toxicity includes poisoning and eye irritation. No other toxicity data have been published. All disinfectants are less effective in the presence of organic material.

Abbreviations: ECE: Early Childhood Education, VOC: Volatile Organic Compounds
[1] The country was based on author location or the date was based on date of publication.

Methods:

A daily scan of the literature (published and pre-published) is conducted by the Emerging Sciences Group, PHAC. The scan has compiled COVID-19 literature since the beginning of the outbreak and is updated daily. Searches to retrieve relevant COVID-19 literature are conducted in Pubmed, Scopus, BioRxiv, MedRxiv, ArXiv, SSRN, Research Square and cross-referenced with the literature on the WHO COVID literature list, and COVID-19 information centers run by Lancet, BMJ, Elsevier and Wiley. The daily summary and full scan results are maintained in a refworks database and an excel list that can be searched. Targeted keyword searching is conducted within these databases to identify relevant citations on COVID-19 and SARS-CoV-2. Additional searches for supporting evidence published prior to the COVID-19 pandemic was conducted by keyword searches of PubMed, using a snowball technique and reviewing reference lists. Search terms used included: Disinfect*, Chemical, Safety, Risk, Child*. This review contains research published up to October 5, 2020. Each potentially relevant reference was examined to confirm it had relevant data and relevant data is extracted into the review.

Prepared by: Dima Ayache & Kaitlin Young. Emerging Science Group, PHAC.
phac.emergingsciencesecretariat-secretariatdessciencesemergentes.aspc@canada.ca

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APPENDIX

Appendix table of common categories of hard-surface disinfectants that comprise the active ingredients in disinfectants used in a range of settings: home, public, hospital [1]

Category (Examples)	Properties and Uses	Potential health impacts: longer term[2]	Safety measures[3]
Chlorine and Chlorine compounds Includes "household bleach" (sodium hypochlorite)- aqueous solution of 5.25%-6.25%, solid calcium hypochlorite. Other compounds designed to hold chlorine longer: demand-release chlorine dioxide, sodium dichloroisocyanurate, and chloramine-T.	Does not leave a residue, inexpensive, fast acting. Rapidly inactivated by organic material. Diluted and applied to surface. Do not mix with: - Ammonia or household cleaning agents as it produces toxic chlorine gas - Formaldehyde and hypochlorite solutions as it produces a carcinogen bis(chloromethyl) ether	Low incidence of serious toxicity. Household bleach (5.25-6.15%) can produce ocular irritation or oropharyngeal, esophageal, and gastric burns. Associated with asthma and other respiratory issues. Chloramines create "organic chloramines" as they attach to organic materials are known as VOCs, studies have shown they increase during household cleaning and some are known carcinogens (Odabasi, 2014). However no adverse effects are expected from normal exposure and proper use.	Diluted household bleach solutions: Use bleach containing 5.25%–8.25% sodium hypochlorite. Do not use a bleach product if the percentage is not in this range or is not specified. Ensure proper ventilation during and after application. Check to ensure the product is not past its expiration date. Never mix household bleach with ammonia or any other cleanser. This can cause fumes that may be very dangerous to breathe in. Prepare a bleach solution by mixing: 5 tablespoons (1/3rd cup) of 5.25–8.25% bleach per gallon of room temperature water or 4 teaspoons of 5.25–8.25% bleach per quart of room temperature water. Bleach solutions will be effective for disinfection up to 24 hours.

Quaternary Ammonium Compound Includes approximately 300 product registrations. Group 1 is hydroxyalkyl substituted quats, Group II non-halogenatred benzyl substituted. Group III is the di and tri-chlorobenzyl substituted quats Group IV are quats with unusual substitutions. (e.g. alkyl dimethyl benzyl ammonium chloride, alkyl didecyl dimethyl ammonium chloride, and dialkyl dimethyl ammonium chloride; twin-chain or dialkyl quaternaries e.g. didecyl dimethyl ammonium bromide and dioctyl dimethyl ammonium bromide).	Non-volatile, leaves residue. Generally approved for disinfection of surfaces and are okay on use of equipment that touches skin. They can be applied as a liquid spray or in a wipe.	No long term health impacts reported: Not dermal sensitizers, not developmental or reproductive toxicants and not carcinogenic or genotoxic (Luz, 2020). Some cases of occupational asthma (e.g. among cleaners) has been reported with exposure to benzalkonium chloride.	Follow the label instructions for use of any disinfectant. Health Canada considers the overall risk benefit prior to approval, ensuring that potential risks can be mitigated by appropriate labelling.
Hydrogen peroxide: Peroxygen, several liquid disinfectants contain hydrogen peroxide. Concentrations range from 6-25% in a premixed -ready to use- chemical. Common combination: 7.5% hydrogen peroxide and 0.85% phosphoric acid.	Leaves residue. Generally approved for disinfection of surfaces. Found in disinfectants at 3-9%. They can be applied as a liquid spray or in a wipe. Is unstable and readily decomposes.	The data on carcinogenicity is inconclusive. Can cause respiratory effects.	Follow the label instructions for use of any disinfectant. Health Canada considers the overall risk benefit prior to approval, ensuring that potential risks can be mitigated by appropriate labelling.
Phenol and phenol derivatives The newer versions-phonolic (chloroxylenol, thymol, O-phenylphenol, triclosan, ortho-phenylphenol ortho-benzyl-para-chlorophenol	Leaves a residue. Generally approved for dis-infection of surfaces. They can be applied as a liquid spray or in a wipe.	Residues can be irritating to skin and dermal absorption is the main route of exposure. Has been linked to hyperbilirubinemia in infants in nurseries using this on bassinettes.	Follow the label instructions for use of any disinfectant. Health Canada considers the overall risk benefit prior to approval, ensuring that potential risks can be mitigated by appropriate labelling.

Peracetic Acid: Peracetic or peroxyacetic	No harmful decomposition products, enhances removal of organic material, leaves no residue, strong pungent odor. They can be applied as a liquid spray. Remains active at low temperatures and in the presence of organic matter. It is unstable when diluted, so should be mixed just prior to use. Can be used in "non-rinse" applications.	Considered a chemical of low concern, low dermal adsorption and no long term health concerns are listed.	Follow the label instructions for use of any disinfectant. Health Canada considers the overall risk benefit prior to approval, ensuring that potential risks can be mitigated by appropriate labelling.
Ortho-phthalaldehyde (OPA or 1,2-benzenedicarboxaldehyde)	Is not a known irritant, no odor, does not require exposure monitoring. Stable at a range of pH from 3-9.	Causes skin staining as it turns proteins gray. Has also been associated with anaphylaxis. Long term exposure is associated with asthma.	Follow the label instructions for use of any disinfectant. Health Canada considers the overall risk benefit prior to approval, ensuring that potential risks can be mitigated by appropriate labelling.
Idophors povidone-iodine aka polybinylpyrrolidone with iodine is most common	Can be used as a surface disinfectant (but better known as an antiseptic). Explodes if mixed with hydrogen peroxide.	Can cause hypothyroidism if ingested in large quantities. Fetus and neonates are particularly sensitive.	Follow the label instructions for use of any disinfectant. Health Canada considers the overall risk benefit prior to approval, ensuring that potential risks can be mitigated by appropriate labelling.

VOC=Volatile organic compounds (VOCs) are compounds that have a high vapor pressure and low water solubility and are emitted as gases from certain solids or liquids. VOCs are released by a wide array of products including paints, cleaning supplies, pesticides, new materials, printers, markers etc. VOCs are higher indoors than outdoors.

[1] Sources: https://www.cdc.gov/infectioncontrol/guidelines/disinfection/index.html, https://pubchem.ncbi.nlm.nih.gov/ and https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/cleaning-disinfection.html

[2]Health impacts related to improper use are not listed: e.g. none of these are safe to ingest, most cause skin irritation and damage to the eye if the product comes in contact with these surfaces. Many of the spray products and bleach also have inhalation warnings during their use.

[3] General safety precautions when using disinfectants: wear skin protection and consider eye protection for potential splash hazards, ensure adequate ventilation, use no more than the amount recommended on the label, use water at room temperature for dilution (unless stated otherwise on the label), avoid mixing chemical products.