Title

Riot Control Agents: Systemic Reassessment of Adverse effects on Health, Mental Stability, and Social Inequities.

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Key terms

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Introduction

In March of 2020, the collaboration of national activist groups increased in mass numbers as the result of the continued killings of innocent Black and Brown lives, such as George Floyd, Breonna Taylor, and Ahmaud Arbery, at the hands of law enforcement and racist citizens (DeGue, et al., 2020). The world responded in sympathetic outrage in protests in the U.S. (**Figure 1**) and globally (**Figure 2**) in at least 40 countries, representing every continent except Antarctica. There is substantial evidence demonstrating that protests have the power to influence public opinion and/or government policy. As early as the 16^{th} century, protests have driven efforts to redefine democracy around the world. Here, during the 1960s U.S. Civil Rights Movement, the power of protests enabled rapid progress towards ending discrimination and engendering equal rights was made possible through the power of protests.

While the size and diversity –which speaks to the heterogeneity of effects of tear gas on individuals– of the protests following the killings of Geoge Floyd, Breonna Taylor, and Ahmaud Arbery seen around the world are historic in their own right, these demonstrations are further distinguished by the risks of spreading Severe Acute Respiratory Syndrome coronavirus 2 (SARS-CoV-2), the strain of coronavirus that causes coronavirus disease 2019 (COVID-19). The Centers for Disease Control (CDC) has identified the main mode transmission of the virus from person-to-person contact and through respiratory droplets (CDC, Coronavirus Disease 2019). In the absence of any pharmaceutical intervention, the only strategy against COVID-19 is to reduce the contact of infected and asymptomatic individuals by following social distancing measures of at least six-feet distance from person-to-person (Lewnard, J.A. and Lo, N.C., 2020). With more than 2,000 cities in the U.S. documenting protests since the death of George Floyd on March 25th, 2020, there is a significant public health concern regarding the increase of COVID-19 cases (Burch, A.D.S. et al., 2020). This is even more concerning, because shortcomings in surveillance and diagnostic capacity combined with the threat of asymptomatic spread indicate that the number of cases reported to date are likely underestimated. The obvious risk of the pandemic is further fanned by the estimated 35% cases of asymptomatic carriers of the virus (Azad, A., 2020).This is of major public health concern because tear gas increases the production of respiratory droplets, and the weapons used to disseminate the gas can inadvertently spread infected respiratory droplets over long distances.

As the frequency of protests rises throughout the world, the demonstration of collectively voicing opposition is widely accepted as a manifestation of exercising the fundamental rights to freedom of expression and peaceful assembly (Haar, R. J., et al., 2017). There is growing literature indicating that the frequent use of riot control agents (RCAs), commonly referred to as 'tear gases' or 'pepper sprays', undermine these freedoms by causing injuries, intimidating communities, and leading to escalations in violence on all sides (Haar, R. J., et al., 2017; Payne-James, J. J., et al., 2011; Alpert G. P., 2004; Bylander, J., 2015). As of June 17, 2020, 100 protests calling for justice for Geoge Floyd, Breonna Taylor, and Ahmaud Arbery, were disrupted by the use of tear gases (**Figure 3**) (Lai, K.K. et al, 2020). The local governments have yet to issue adequate safety and warnings of tear gas use. This not only raises an ethical, but moral question: If we cannot use tear gas on our enemies, why is it acceptable to use on our own citizens? When unarmed civilians, children, people with disabilities, and members of the press exercise their First Amendment rights, why are they being exposed to chemical weapons that we do not even use on the battlefield? Children, people with disabilities, and members of the press all risk permanent health effects from these chemical weapons, despite its "non-lethal" label. In this review, we show that tear gas causes biological (adverse health side effects), ecological (adverse environmental effects), mental distress (i.e. risk of anxiety, post-traumatic stress syndrome following exposure), and inequalities. These permanent effects go beyond mere crowd control; using tear gas to disrupt protests must be banned.

Methods for Search Strategy and Selection Criteria

A literature review was conducted in June 2020 using PubMed, Ovid, Science Direct, and Google Scholar with the following descriptors: Tear gas, management of tear gas, clinical features and side effects of CS, use of CN versus CS, pepper spray containing OC, Emotional distress from tear gas exposure, psychiatry outcomes from tear gas, review, insidious racism, excessive use of force, quantitative/qualitative protest data, environmental effects of tear gas, and coronavirus. Results obtained ranged between 0 and 827 manuscripts were available after the combination of different keywords. Scientific publications between 1990 and 2020 either in English discussing the mechanism of tear gas, toxic effects of tear gas, environmental damage, excessive relating to protests, and coronavirus reviews were selected. Articles concerning molecular pathways of tear gas, review papers not detailing how tears affect health, the environment, and mental health were excluded. Additionally, manuscripts discussing excessive police force outside of the scope of protests were excluded.

Results

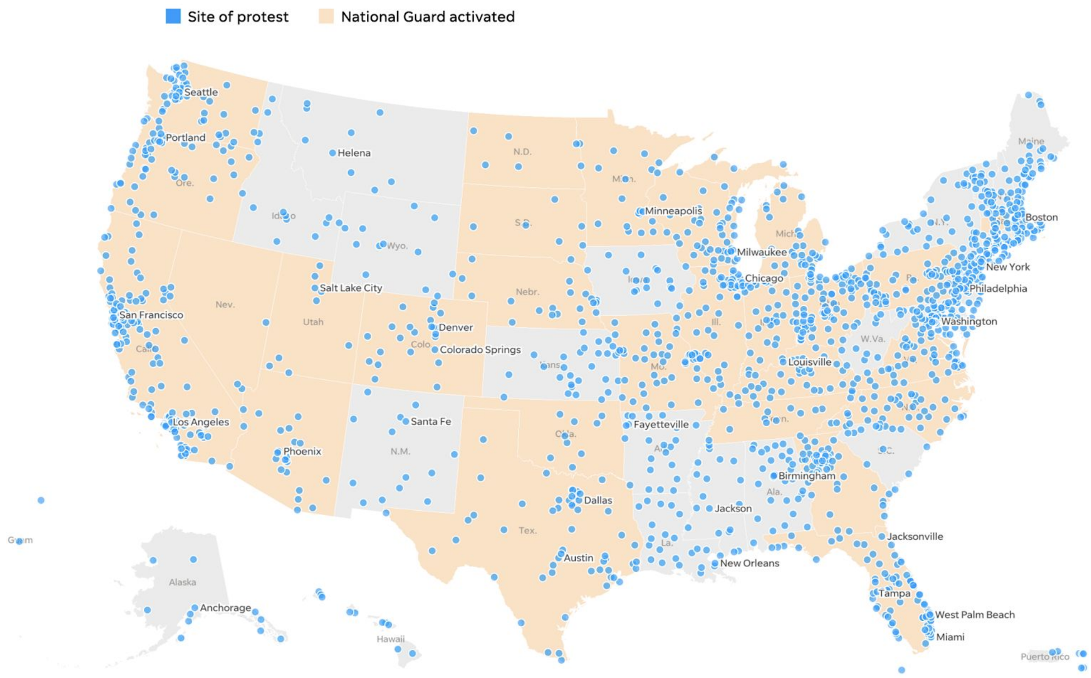

Figure 1. Protests across the United States following the death of George Floyd.
Unprecedented protests broke out across the U.S. in the wake of the police killing of George Floyd in 2020. Demonstrators came out by the thousands in all 50 states, not only in metropolitan areas, but also in white suburbs, small towns and surrounding territories.
USA Today. 2020. Tracking protests across the USA in the wake of George Floyd's death. Accessed June 18th, 2020.
https://www.usatoday.com/in-depth/graphics/2020/06/03/map-protests-wake-george-floyds-death/5310149002/

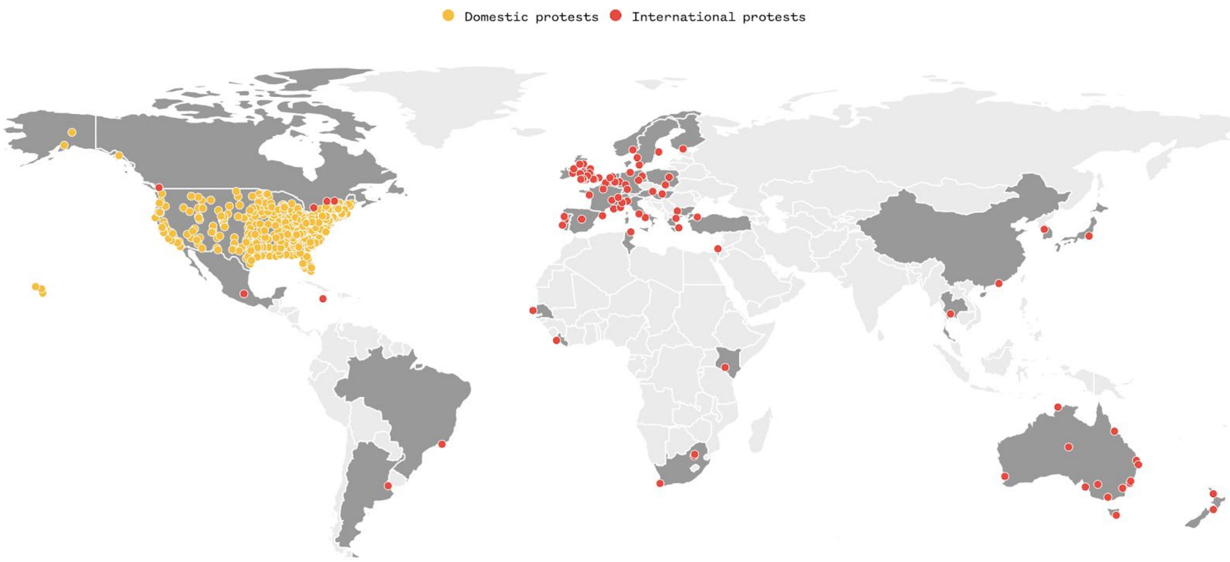

Figure 2. Protests around the world following the death of George Floyd spranning 40 countries representing every continent on the globe, except Antarctica.
NBC News. 2020. George Floyd protests around the world. Accessed June 12th, 2020.

Figure 3. Cities in the U.S. where the use of tear gas was documented to disrupt protest as of June 18th, 2020.
The New York Times. 2020. Here are the 100 U.S. Cities where Protestors were Tear-Gassed. Accessed June 18th, 2020.
https://www.nytimes.com/interactive/2020/06/16/us/george-floyd-protests-police-tear-gas.html

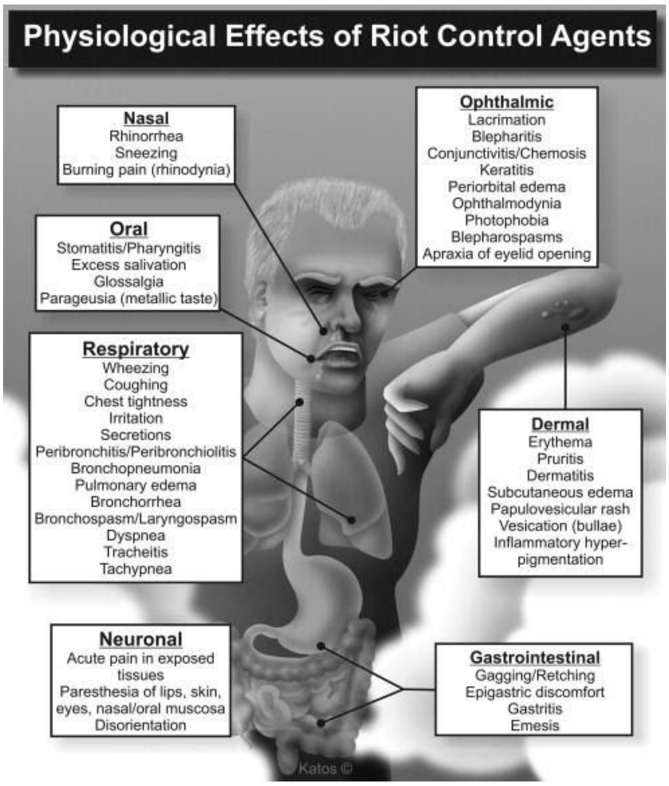

Figure 4. Physiological Effects of Riot Control Agents. Illustrated, copyright protected by Alexandre M. Katos (Hilmas, C. J., et al., 2009).

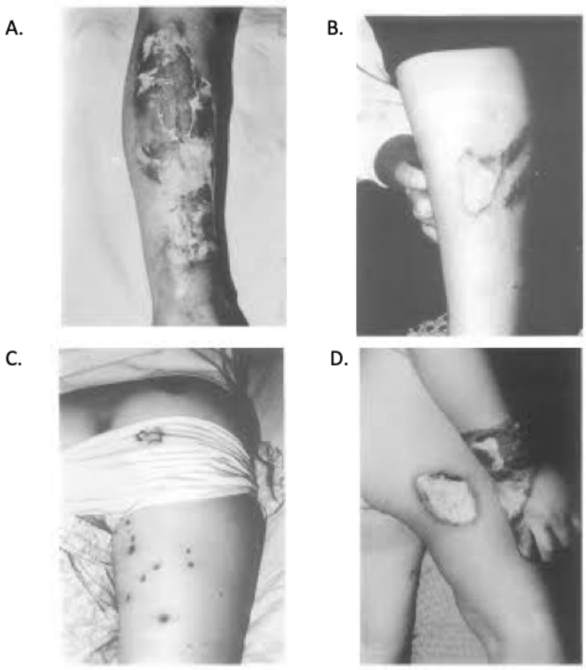

Figure 5. Mass Burns caused by CS gas.
A) Large burn injury of the leg from the explosion of a CS grenade. B) Contact burns of the forearm caused by the hot canisters. C) Chemical Burns of the buttock and the thigh caused by the powder splashing clothes and the skin in contact. D) CS chemical burn injury on the

thigh and the hand of a 5 year old boy, requiring debridement and skin grafting. Figure copyright protected by (Zekri, A. M., et al., 1995).

Table 1. Patient Demographics, Neurologic Examination, Computed Tomography Scan Findings, Management, and Outcomes

Patient Number	Age (years)	Sex	GCS Score on Admission	Pupil Reactivity	Unilateral Weakness	Wound (Entry Site)	CT Scan Findings*	Surgery†	Time Until Death (Days)
1	14	Male	10	Normal	No	Right frontal	Canister in R frontal lobe across the midline	Yes	1
2	17	Male	9	Normal	No	Right frontal	Canister in R frontal lobe across the midline	Yes	1
3	15	Male	9	Normal	No	Right frontal	Canister in R frontal lobe	Yes	3
4	18	Male	8	Normal	Right	Left occipital	Canister in L occipital lobe and basal ganglia region	Yes	3
5	19	Male	8	Normal	No	Midline occipital	Canister in both occipital lobes across the midline	Yes‡	1
6	16	Male	6	DNRP (R)	Left	Right parietal	Canister in R parietal and frontal lobes	Yes	2
7	17	Male	3	DNRP (bilateral)	NA	Left parietal	Canister in bilateral parietal lobes across the midline	No§	1
8	15	Male	3	DNRP (bilateral)	NA	Right parietal	Canister in R parietal and frontal lobes	No§	1
9	16	Male	7	DNRP (L)	Right	Left parietal	Canister in L parietal and occipital lobes	Yes	3
10	16	Male	7	DNRP (R)	Left	Right parietal	Canister in R parietal lobe	Yes	2

All patients had a combination of the following: skull fractures, intraparenchymal bone fragments, multiple brain contusions, brain edema, pneumocephalus, intraventricular hemorrhage, tract hemorrhage, and subarachnoid hemorrhage. Notably, all patients had brain tissue through the scalp wound.
GCS, Glasgow Coma Scale; CT, computed tomography; R, right; L, left; DNRP, dilated nonreacting pupil, NA, not applicable.
*Indicates unique CT scan findings.
†Surgery included canister removal with wound debridement and closure.
‡In this patient the canister could not be removed because of profuse bleeding from the straight venous sinus.
§Cases were not treated with surgery, only a simple wound closure was done.

Figure 6. Fatal Penetrating Head Injuries Caused by Projectile Tear Gas Canisters. Figure copyright protected by (Hoz, S .S, et al., 2020).

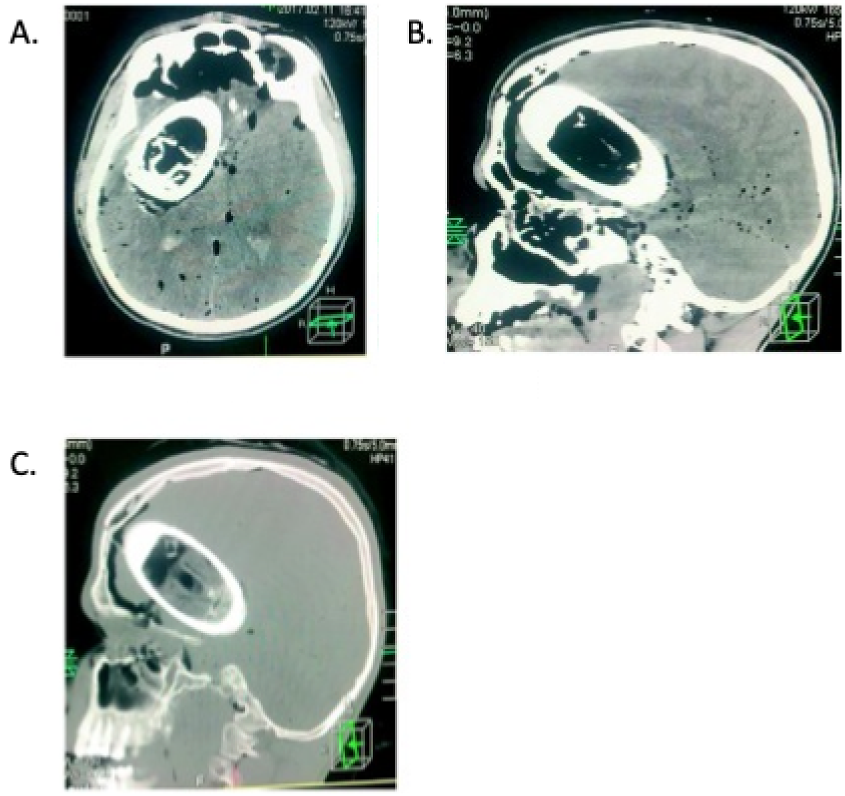

Figure 7. Initial CT scan of the brain, (A, B,) Brain (soft tissue) axial and sections, (C) Bone window section, sagittal view; show a large oval well-circumscribed hyper-dense mass with hollow cavity settled inside in the right frontal and temporal region representing a foreign

body inside the skull and causing brain edema, intraventricular hemorrhage, widespread pneumocephalus, intracranial bone chips and midline shift. (Alhillo, H. T., et al., 2018).

Figure 8. Say their Names Chart presenting the local (Portland, Oregon) and national (U.S.) cases of gun violence and police brutality by way of excessive use of force (Morman, A. 2020).

Discussion

History of Riot Control Agents

Since the creation of tear gas in the 1920s, scientists and medical professionals have published articles justifying the use of tear gas as a common riot-control agent (RCA) to quell protests, riots, and civil unrest (Rothenberg, C., et al., 2016). These manuscripts showed that tear gas, whether made from o-chlorobenzylidene malononitrile (CS), 2-Chloroacetophenone (CN), or oleoresin capsicum (OC) has a large safety margin for life-threatening or irreversible toxic effects (Rothenberg, C., et al., 2016). Meaning these chemical irritants were suggested to be nonlethal and the risk of significant medical effects from exposure is unlikely. However, the manuscripts that were reviewed require the compounds to be specifically defined. There is growing empirical, scientific evidence that conflicts with previous, more theoretical, reports. For example, the term irritant as defined by the City of Portland is tear gas, mace, pepper spray, or any similar deleterious agent capable of generating offensive, noxious or suffocating fumes, gases, or vapor capable of producing temporary discomfort, permanent injury, paralysis, immobilization, tears, nausea, or other illness. Currently, several articles stressing the risks of tear gas exposure are understated and that the perceived risks are based on insufficient human epidemiological and mechanistic data with regards to a spectrum of health effects (Rothenberg, C., et al., 2016). Despite the frequency of their use since the 1960s, there has been limited analysis of their mechanisms of injury and potential lethality and longer-term morbidity (Hughes, E. and Osborne R. et al., 2010). Consequently, there is a significant gap in the knowledge of treatment plans, countermeasures, and the medical understanding of the long-term effects of using tear gas in riot-control (Rothenberg, C., et al., 2016).

Irreparable Harm

Physiochemical, Biological, and Ecological Hazards of Tear Gas contents

Modern RCAs are crystalline solids with low vapor pressure (Hilmas, C. J., et al., 2009). RCAs are typically administered as fine particles, aerosols sprays, or in solutions, therefore they are not pure gases (Hilmas, C. J., et al., 2009). Prior to dispersion, tear gas is found in a solid form at room temperature (Rothenberg et al., 2016). To convert the chemical compounds from solid to a gas, additional chemicals must be used to catalyze the chemical reaction and devices such as grenades, canisters, or pressurized dispensers must be used to deploy RCAs as aerosols (Olajos, E.J. and Stopford, W. 2004). The reaction of converting a solid to a gas state, bypassing the liquid state, or sublimation, is mediated by numerous toxic chemicals such as pyrotechnic mixtures in grenades and canisters, methyl isobutyl ketone (MIBK or hexane) in pressurized dispensers, in addition to alcohols, organic solvents, halogenated hydrocarbons, and propellants such as freon, tetrachloroethylene, and methylene chloride (Olajos, E.J. and Stopford, W. 2004; Smith, J. and Greaves, I. 2002, CDC). The mixture of these toxic chemicals is of concern for two reasons: firstly, these solvents, such as tetrachloroethylene and methylene chloride, enable deeper skin penetration as well as larger quantities of an irritant to be dissolved and dispersed, potentially exacerbating some of the effects. Secondly, these compounds are highly toxic to humans and the environment (Vilke G.M., and Chan T.C., 2007; Bir, C., 2015; Associated Press, *Spain: Police Fired Rubber Bullets at Migrants*; International Business Times, Migrant crisis: Hungary approves use of army, rubber bullets and tear gas against refugees, 2015; Daily BBC,Turkish police use tear gas, water cannon to disperse protest in Ankara 2013).

CS

For example, mounting evidence demonstrates that the harmful chemical MIBK results in more adverse side effects than CS itself (Smith and Greaves, 2002; Rothenberg et al., 2016; NCBI, Methyl Isobutyl Ketone). According to the American Chemical Society, MIBK is a solvent for manufacturing paints, rubbers, pharmaceuticals, and industrial cleaners. MIBK uses include dissolving resins found in paints, inks, lacquers, and other types of surface coatings. Exposure of MIBK results in irritation to the eyes and skin, causing erythema, flaking, or blistering that may appear up to 8 hours after exposure and last up to a week (Smith and Greaves, 2002). This is much longer than the side effects from exposure of CS alone which is 15 minutes after cessation of exposure (Karagama et al., 2003).

Not only are MIBK's temporary side effects more severe than CS, there are several reports demonstrating the toxicity of MIBK. In February 2007, the National Toxicology Program (NTP) issued its final technical report (TR-538) on toxicology and carcinogenesis studies on the inhalation of MIBK in rats and mice. Under the conditions of these two-year studies, NTP researchers determined that there was some evidence of carcinogenic activity of MIBK in male F344/N rats. They also determined that there was equivocal evidence of carcinogenic activity of MIBK in female F344/N rats and that there was some evidence of carcinogenic activity of MIBK in male and female B6C3F1 mice (American Chemistry Council, Methyl

Isobutyl Ketone (MIBK), 2020). Reports dating back to 1982 by Bellanca et al., detected MIBK in the brain, liver, lung, vitreous fluid, kidney, and blood in two workers who died after exposure to several organic solvents during spray painting (Bellanca et al., 1982). Dowty et al., reported MIBK in human maternal blood samples collected immediately after delivery, indicating the potential for the compound to enter the umbilical cord and cross the placenta (Dowty et al. 1976).

For "CS" tear gas, the typical pyrotechnic composition for the dissemination of CS consists of 45% CS agent, 30% potassium chlorate, 14% epoxy resin, 7% maleic anyhdride, 3% methyl nadic anhydride, and 0.03% mixed residual balance (Ledgard J., 2007). Several of these compounds are highly toxic. For example, CS gas comprises two components that react with one another, 2-chlorobenzaldehyde and malononitrile. 2-chlorobenzaldehyde has been cited by the NTP as a corrosive material that emits toxic fumes when heated to decomposition (NTP, 1992). It is also toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment (ThermoFisher Scientific. 2018. Safety Data Sheet, 2-chlorobenzaldehyde). Therefore, the material data safety sheets (MSDS) states not to flush 2-chlorobenzaldehyde into surface water or sanitary.

The second compound of CS is malononitrile (Cameo Chemicals Safety Data Sheet, malononitrile), which is classified as extremely toxic.The MSDS reported a probable oral lethal dose for humans is 5-50 mg/kg, or between seven drops and one teaspoonful, for a 70 kg (150 lb.) person (Cameo Chemicals Safety Data Sheet, malononitrile; EPA, 1998). The MSDS also stressed that malononitrile may be fatal if inhaled, swallowed, or absorbed through the skin or mucous membranes. The MSDS sheet states when malononitrile is metabolized after exposure, it is broken down to cyanide and thiocyanate. Consequently, the effects of inhalation of toxic fumes will be related to cyanide. Adverse side effects reported on the MSDS are brain and heart damage related to a lack of cellular oxygen. All occur in the exposure of tear gas. In addition to the common side effects of tear gas, acute exposure of malononitrile causes adverse symptoms such as hypertension (high blood pressure) and tachycardia (rapid heart rate), followed by hypotension (low blood pressure) and bradycardia (slow heart rate). Other symptoms include anxiety, confusion, tightness in the chest, and involuntary urination and defecation, headache, vertigo (dizziness), agitation, convulsions, paralysis, protruding eyeballs, dilated and unreactive pupils, unconsciousness and coma, lung hemorrhage and pulmonary edema may also occur.

According to its MSDS, potassium chlorate is a dangerous oxidizing agent that is explosive when mixed with combustible materials (FSC Image Safety Data Sheet, potassium chlorate). As noted above, he largest part of CS is composed of 2-chlorobenzaldehyde, which is considered a highly combustible material. Potassium chlorate is also toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment. Potential health effects from acute exposure include conjunctivitis, permanent corneal opacification, methemoglobinemia, cyanosis (bluish discoloration of the skin due to deficient oxygenation of the blood), convulsions, tachycardia, dyspnea (labored breathing), acute pulmonary edema, asphyxia, chemical pneumonitis, and upper airway obstruction caused by edema, and death. Chronic exposure may cause liver and kidney damage, methemoglobinemia (chocolate-brown colored blood), headache, weakness, dizziness, breath shortness, cyanosis (bluish skin due to deficient oxygenation of the blood), rapid heart rate, unconsciousness, and possible death.

CN

CN is a crystalline solid with a strong, pungent odor (Hilmas, C. J., et al., 2009). It is dispersed as a smoke, powder, or liquid formulation from grenades or other devices (Hilmas, C. J., et al., 2009). CN or Mace® was the most commonly used RCA for personal protection until the 1950s (Rothenberg, C., et al., 2016). Since the mid 1970s, it has been well documented that CN is three- to ten-fold more toxic than CS in rats, rabbits, guinea pigs, and mice making CN the most toxic among RCAs in use today (Ballantyne and Swanston, 1978). Consequently, it has been replaced by the less-toxic CS for riot control and capsaicin pepper spray for self-defense (Hilmas, C.J., et al., 2009).

OC

OC, commercially labelled pepper spray, is an oily resin derivative from capsicums from pepper plants of the genus Capsicum, commonly referred as chilli pepper (Hilmas, C. J., et al., 2009). OC gained popularity in the 1990s as a defensive weapon for civilians and law enforcement agencies because they produce an immediate, temporary immobilization and incapacitation when sprayed directly into the face or eyes (Hilmas, C. J., et al., 2009). There are five naturally occurring capsaicinoids: capsaicin, dihydrocapsaicin, nordihydrocapsaicin, homocapsaicin, and homodihydrocapsaicin. The most pungent capsaicinoid analogues are capsaicin and dihydrocapsaicin. Consequently, together they constitute 80% to 90% of the total concentration in pepper spray products (AFP 2013; Lowery, W., 2014). The absolute and relative abundance of each capsaicinoid analogue varies in fresh peppers and therefore in OC spray products themselves (Rothenberg et al., 2016). Unfortunately, hand-held pepper spray formulations can contain OC by themselves or a mixture of OC and CS. Consequently, pepper spray can result in adverse effects due to the variability in dosing and compounded effects of being exposed to two toxic chemicals (OC and CS) simultaneously (Rothenberg, C., et al., 2016).

Physiological reaction to tear gas

Thus far, there has been inadequate research on the safety of tear gas. Most of the literature with human subjects contain small sample sizes and only include healthy individuals in controlled conditions (Kastan B., 2012; Dagli E. E., et al., 2016). For example, a study conducted by Hu et al., 1989 concluded that tear gas exposure was not associated with increased airway resistance. It is important to stress that the study was conducted on a sample of only seven healthy military volunteers, and those with a history of chronic respiratory illness were excluded (Hu, H., et al., 1989). Because the demographic of the study is not representative of the heterogeneous sample observed during the use of RCAs, the conclusion drawn cannot be applied to the safety of using tear gas on the general public.

When examining real-life examples of tear gas use in riots or instances of large-scale civil disorder, there is evidence where extended, repeated, or highly concentrated exposures pose a greater threat to respiratory health (Olajos E.J., and Stopford W., 2004; Dagli et al., 2016). Extended, repeated, or highly concentrated exposures are of significant concern for the police officials who are dispersing the tear gas during recent protests and the houseless and protesters who are repeatedly exposed to RCAs. Several studies have shown that high concentrations of CS or OC can cause severe respiratory symptoms, such as reactive airways dysfunction syndrome (RADS) (Zekri et al., 1995; Roth, V.S., and Franzblau A., 1996; Anderson P.J. et al., 1996). The development of RADS is a significant public health concern because it is a poorly understood condition that mimics asthma, but appears unresponsive to asthma treatments (Varney, V. A., et at., 2011). Consequently, there is a lack of standardized treatment of care for these patients (Varney, V. A., et at., 2011). Even more alarming is if symptoms persist for more than 6 months, there is a risk that they can become chronic (Varney, V. A., et at., 2011). For these cases, effective treatments are lacking and quality of life is poor (Varney, V. A., et at., 2011). Similar results were documented from high concentration exposure to CN, where infiltration of the lower respiratory tract can induce pulmonary edema, apnea, and respiratory arrest (Tuorinsky S.D., and Sciuto A.M., 2008).

Additionally, data after recent massive-scale tear gas deployments in Turkey revealed persistent cough, chest pain, sputum production, hemoptysis, breathing difficulties, and nasal discharge, sometimes lasting for weeks after exposure (Dagli, E. E., et al., 2014). Further testing examining lung function revealed restriction and medium and small airway obstruction were more severe in women (Dagli, E. E., et al., 2014). It is important to note, residents in the area where tear gas was deployed experienced respiratory effects, suggesting that tear gas agents represent a persistent environmental health hazard (Dagli, E. E., et al., 2014). Also, a study by Arbak P., et al., with 93 males frequently exposed to tear gas and 55 unexposed subjects found that tear gas–exposed subjects were at greater risk for chronic bronchitis (Arbak P., et al., 2014).

Further support of adverse effects following tear gas exposure was supported by an U.S. army epidemiological study where they analyzed health effects in more than 6,000 army recruits exposed to CS in chambers during a gas mask confidence training. The results yielded unexpected respiratory risks linked to tear gas exposures in a relatively young and healthy population. After exposure, there was a high risk of presenting with acute respiratory illness, with increasing risk at higher exposure concentrations (Hout J. J., et al., 2014). Adverse side effects of respiratory illness included throat pain, cough, bronchitis, nasopharyngitis, sinusitis, and other indications. CS exposures were also associated with an increase in respiratory infections, including influenza (Hout J. J., et al., 2014). These findings led to immediate measures limiting exposure concentrations and times, improving decontamination procedures, and imposing frequent hygiene and health monitoring for U.S. soldiers. However, these precautions were not translated to non-civilian use.

On a molecular level, much of the respiratory effects are due to changes in mucociliary transport, which plays an important role in the defense against organic and inorganic particulates, and gaseous material (Sleigh, M. A., et al., 1988). Structural abnormalities of the respiratory cilia, alterations in the properties of the mucus, and impairment of the ciliary beat frequency (CBF) may impair mucociliary function (Wanner, A., et al., 1996). Many studies have revealed that inhalation of gases or aerosols of several compounds induced cilioinhibition (Wanner et al., 1996). Cilioinhibition may contribute to the accumulation of these compounds in the airways, promoting their adverse effects.

Respiratory Toxicity

The most common route of CS or CN absorption is by inhalation. Inhalation of RCAs causes burning and irritation of the airways leading to cough, chest tightness, dyspnea (Beswick, 1983; Hu, H., et al., 1989; Blain, P.G., 2003), shortness of breath (Euripidou, 2004), bronchospasm (Hu H., and Christiani, D., 1992), and bronchorrhea (Folb, P.I., and Talmud, J., 1989). Paroxysmal cough, shortness of breath, and chest tightness, characteristic of reactive airway disease, have been demonstrated to last up to several weeks post-exposure. Pulmonary effects typically resolve by 12 weeks post-exposure. Pulmonary edema may occur up to 24 hours post-exposure (Stein and Kirwan, 1964; Gonmori *et al.,* 1987). Laryngospasm, sudden spasm of the vocal cords, can occur immediately or 1 to 2 days after CS or CN exposure. Reactive airways are associated with high-level exposure to CS (Blain, P.G., 2003). Delayed onset laryngotracheobronchitis 1-2 days post-exposure, characterized by wheezing, dyspnea, tachypnea, hoarseness, fever, and purulent sputum, was reported in high concentrations of CN (Thorburn, K.M., 1982). CN typically causes an acute, patchy, inflammatory cell infiltration of the trachea, bronchi, and bronchioles, in addition to early bronchopneumonia. (Hilmas, C. J., et al., 2009)**.**

Also, inhalation of ROC agents exacerbates underlying pulmonary disease such as asthma, emphysema, or bronchitis. Histories of asthma and chronic obstructive pulmonary disease may exacerbate effects from CS (Hilmas, C. J., et al., 2009; Worthington E., and Nee, P., 1999) or CN (Hilmas, C. J., et al., 2009; Thorburn, K.M., 1982). CS may exacerbate chronic bronchitis or precipitate an attack in known asthmatics (Rothenberg, C., et al., 2016). Long-term bronchodilator therapy was required in one patient with pre-existing pulmonary disease. Pathological findings in the lungs tend to be more severe and CN causes far greater edema.

Risks of spreading COVID-19 through increase in respiratory droplet production and dispersion by RCA weapons

COVID-19 is a systemic disease that primarily injures the vascular endothelium, which can result in lung complications such as COVID-19 pneumonia and COVID-19 Acute Respiratory Distress Syndrome (CARDS) (Marini J., and Gattinoni, L., 2020). The increased risks of contracting COVID-19 during protests are further exacerbated by the use of tear gas. At present, the novel COVID-19 has caused a large number of deaths with 8.24 million confirmed cases worldwide, resulting in 446,000 deaths (CDC, Coronavirus Disease 2019).

According to the CDC and WHO, the COVID-19 virus is primarily transmitted between people through respiratory droplets, which are produced in high frequency due to exposure of tear gas (WHO, Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations, 2020). Droplet transmission occurs when a person is in close contact (within 1 m) with someone who has respiratory symptoms (e.g., coughing or sneezing) and is therefore at risk of having his/her mucosae (mouth and nose) or conjunctiva (eyes) exposed to potentially infective respiratory droplets (WHO, Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations, 2020). The CDC has stated the airborne transmission may be possible in specific circumstances and settings in which procedures generate aerosols. Coughing and sneezing produce greater quantities of these particles that travel further due to the velocity of expulsion from the nose or mouth (Thomas R.J., 2013; Duguid J. P., 1945; Loudon R.G., and Roberts R.M., 1967; Zhou B., et al., 2005).

At least 100 law enforcement agencies, many in large cities, deployed some form of tear gas against civilians protesting racism and police brutality in recent weeks (**Figure 3**). This is of major public health concern because, firstly the weapons used to disseminate the gas can inadvertently spread infected respiratory droplets. These weapons are designed to aerosolize tear gas into microencapsulated aerosols ranging from 3 to 10 μm. According to the World Health Organization (WHO), COVID-19 can be transmitted through droplets particles sized >5-10 μm in diameter, which is in the range of the droplets that are propelled by tear gas weapons (WHO, Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations, 2020). Secondly, tear gas induces the production of tears, mucus, and coughing which increases the likelihood of infected respiratory droplets being produced which can land in the mouths or noses of people who are nearby or possibly be inhaled into the lungs (Rothenberg, C., et al., 2016). It is important to emphasize that this is a strong possibility due to the chaotic nature of being exposed to tear gas since tear gas can engage targets up to 400 meters away and has a dispersion area ranging from 60 to 300 $meters^2$ (Rothenberg et al., 2016). As RCAs, such as tear gas, affect the senses, it is common for individuals to become disoriented after exposure, causing temporary loss of balance and orientation after exposure (Hilmas, C. J., et al., 2009; Thorburn, K.M., 1982). Additionally, panic and agitation are common, especially after the first exposure (Schep L.J., et al., 2013). People are more likely to be in close contact with one another to aid those in distress, seek medical attention, and find safety. Lastly, persons who are already infected are likely to be at a much higher risk of mortality due additional pulmono-inflammatory burden introduced by these chemical inhalants. Consequently, the use of tear gas in the midst of the COVID-19 pandemic is of grave concern.

Ocular effects

The eyes are a major target for RCAs. Eye toxicity findings from RCA can range in severity from conjunctival erythema to ocular necrosis (Hilmas, C.J., et al., 2009). Generally, tear gas deployed at close range can cause severe ocular injuries, including corneal stromal edema, conjunctival tearing, and deep vascularization of the eye (Gray P. J., and Murray V., 1995). Other ocular complications included vitreous hemorrhage, traumatic optic neuropathy, symblepharon, pseudopterygium, infective keratitis, trophic keratopathy, glaucoma, and cataracts (Gray P. J., and Murray V., 1995). Additionally, because RCAs are solids, the chemicals can clump together penetrating into corneal or conjunctival tissues, particularly if individuals are close to the weapons when the tear gas is discharged (Levine R. A., and Stahl, C.J., 1968).

After CS exposure, ocular effects include erythema and edema, which may last up to 48 hours and vascularizing keratitis (Ballantyne B., et al., *1974),* but symptoms generally subside after 30min (Beswick, F.W., 1983). Many of these effects depend on the concentration and duration of exposure (Blain, P. G., 2003). The conjunctivae may even progress to fulminant conjunctivitis and blurred vision (Euripidou E., et al., 2004).

CN causes a similar constellation of ocular signs and symptoms as CS, but CN toxicity is likely to be more severe in the eyes and skin. CN sprayed into the eyes from a distance causes lacrimation, edema of the corneal epithelium and conjunctivae, and reversible epithelial defects of the cornea (Leopold, I.H., and Lieberman, T.W., 1971). At close range, CN can cause long lasting and permanent damage to the eye. Toxic signs in the conjunctivae from CN include conjunctivitis, sloughing, limbal ischemia, and symblepharon formation (Scott, R. A., 1995). Permanent eye injury is unlikely except after exposure to high concentrations (Grant, W. M., 1986). Long-term sequelae may include cataracts, vitreous hemorrhage, and traumatic optic neuropathy (Gray, P. and Murray, V., 1995).

There are substantial reports demonstrating corneal effects from particulate CN exposure. Clumps of CN can result in possible penetration of the corneal stroma, severe scarring and ulceration, and deficits in the corneal reflex (Blain, P. G., 2003; Scott, R. A., 1995).

Penetration of the corneal stroma may lead to stromal edema and later vascularization, resulting in further ocular complications. These may include pseudopterygium, infective keratitis, symblepharon, trophic keratopathy, cataract hyphema, posterior synechia, secondary glaucoma, vitreous hemorrhage, and traumatic optic neuropathy (Hoffman, D. H., 1967).

Skin burn and dermatitis

There are several reports demonstrating CS exposure can result in first and second degree skin burns (**Figure 5**), especially when large quantities are used (Zekri et al., 1995; Anderson P.J. et al., 1996; Stein, A. A., and Kirwan, W. E., 1964; Weigand, D.A., 1969; Hu H., et al., 1989). Erythema is often the first sign of contact dermatitis, occurring minutes after exposure and subsiding about an hour after exposure (Hilmas, C.J. et al., 2009). However, severe skin reactions in response to CS exposure can include severe facial erythema and swelling that obscured vision (Varma, S., and Holt, P.J., 2001). The Department of Dermatology at San Francisco General Hospital reported severe CS induced erythematous dermatitis of the face, neck, and hands in several of their patients (Parneix-Spake, A. A., et al., 1993). Cases of allergic contact sensitization, a delayed hypersensitivity reaction delayed from a previous exposure to RCAs, were reported with erythematous patches and multiple vesicular eruptions on the skin following heavy exposure to CS (Ro Y. S., and Lee, C.W., 1991) Allergic sensitization was further supported by a study examining workers of a plant manufacturing CS. Ninety percent of workers reported a history of dermatitis on the arms and neck, with 7% showing positive patch-test reactions to CS, suggesting that CS may act as a contact sensitizer (Shmunes, E., and Taylor J.S., 1973). Also, CN is a more potent irritant than CS (Hilmas, C.J. et al., 2009). CN not only demonstrates greater irritation to the skin than CS, it is also a more potent skin sensitizer (Chung, C.W., and Giles, A.L., 1972). Patients frequently exposed to CN are at a high risk of developing allergic dermatitis (Penneys, N.S., 1971).

Gastrointestinal Toxicity

There are several clinical reports demonstrating CS and CN induces nausea, vomiting (emesis), and alterations in taste after exposure (Solomon, I., et al., 2003; Athanaselis, S., et al., 1990; Thorburn, K. M., 1982; Blain, P. G., 2003). Vomiting occurs if the individual is sensitive, the concentration of RCAs are sufficiently high, the exposure prolonged, the range is close, or the event occurs in a confined space (Hilmas, C.J., et al., 2009). In one case, vomiting did not resolve until the following week in one patient. Inhalation of RCAs often leads to a metallic or burning sensation resulting in altered taste of the tongue (Folb, P. I., and Talmud, J., 1989).

Variability in Dosing

The variety of chemical agents used to convert tear gas from the solid form to gas, the concentration of chemicals, unit sizes, and delivery mechanisms used in crowd control further complicates the analysis of the short and long-term effects following exposure. The standardization of the chemicals used in these irritants are not overseen by any governing body, partly because they are manufactured by many companies around the globe in countries such as Brazil, China, Israel, South Korea, and several other countries (Omega Research Center; U.S. Department of Justice). Additionally, a report by the Committee on Acute Exposure Guideline Levels, Committee on Toxicology, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies, National Research Council revealed the volume and concentration of chemicals in each spray and aerosol varied considerably among manufactures and countries (Metress E.K., and Metress S.P., 1987). Also, there are several studies that discovered the concentrations of OC may be misleading because the potency of OC is dependent not only on the concentration within a solvent but on the strength of the capsicum extracted (Rocke, L., 2014; Associated Press; Cohen, G., Huffington Post). Also, the dose of tear gas exposure of individuals may be markedly increased by the use of multiple grenades and/or canisters at the same location over a short period of time or in areas where people cannot easily escape. Due to these compounding effects, the dose levels for symptoms, toxic effects, and lethal outcomes of tear gas are difficult to determine.

Severe injury and deaths

Human deaths have been reported from RCA exposure (Thorburn, K.M., 1982; Ferslew, K., *et* at., 1986; Danto, B., 1987). The cause of death is usually the result of excessive RCA concentrations, confined spaces, and/ or prolonged exposures. Death occurs hours after initial exposure, and post-mortem findings are consistent with severe airway damage seen in animals (Hilmas, C. J., et al., 2009). Many of the deaths from CS and OC were in the prison systems due to the use in enclosed and poorly ventilated spaces, pre-existing respiratory conditions of prisoners, and the lack of decontamination following use (Thorburn, K.M., 1982; Stein, A. A., and Kirwan W.E., 1964; Champman, A.J., and White, C., 1978; Brown, J. K., 2014). Another case is of a 43-year-old man who developed pulmonary edema complicated by pneumonia, heart failure, and hepatocellular damage after CS intoxication (Krapf, R., and Thalmann, H.,1981). One OC-caused death involved an inmate who died in custody and another during an aggravated arrest (Steffe *et* al., 1995).

There have been numerous incidents where the use and misuse of the weapons used to deploy the chemicals have resulted in serious injuries and even death (Hoz, S.S. et al., 2020; Billmire, D. F., et al., 1996; Cil, H., et al., 2012; Gerber, S., et al., 2011; Haar, R. J., et al., 2017). Severe injuries and deaths have been reported during the massive-scale deployments of RCAs in several countries such Iraq, Egypt, Turkey, Bahrain, and Brazil. These were often caused by direct or close impact of tear gas ammunition causing severe head, eye injuries, and burn (**Figure 6**) (Clarot, F. E., et al., 2003; Atkinson, H. G., and Sollom, R., 2012).

A standard tear gas dispersion weapon is usually composed of a host of chemicals (tear gas), methylene chloride (dispersal agent), and the canister which contains a detonator and a propellant to fire the projectile (Hoz, S. S., et al., 2020). The deployment velocity, and hence the damage caused by the cartridge are determined by both the firing device, distance from the target, ammunition type, firing angle, concentration of the chemicals, and the surrounding environmental conditions (Hoz, S. S., et al., 2020 1 6). A recent systematic review of disabilities attributed to projectile tear gas canisters by Hoz et al., revealed 2 fatalities and 48 permanent disabilities in Iraq alone (Hoz, S. S., et al., 2020 6). Numerous case reports have recorded serious injuries caused by projectile tear gas ammunition, including globe injuries, blindness, maxillofacial wounds, and closed traumatic brain injuries (**Figure 7**) (Hoz, S.S., et al., 2020; Clarot, F., et al 2003; Corbacioglu, S. K., et al., 2016; Yih, J., 1995; Wani, A. A., et al., 2010). The head CT scans of the 41 patients revealed extensive injuries which included multiple skull fractures, in-driven bone fragments, multiple brain contusions, diffuse brain edema, pneumocephalus, intraventricular hemorrhage, tract hemorrhage, and subarachnoid hemorrhage (Hoz, S. S., et al., 2020). The authors concluded that tear gas weapons have the potential to inflict serious injuries and death. Consequently, tear gas and the weapons used to disperse RACs should be banned and strict standard operating protocols, dosage, and safety guidelines are required before the use of these weapons can be used again.

The Use of Riot Control Agents on Mental Health

There is a significant gap in knowledge in the connection between mental health and the use of tear gas. Upon conducting a literature search on Pubmed. gov, several searches using the key terms psychiatry and tear gas yielded three manuscripts. Additional key searches were conducted using psychology and tear gas and anxiety and tear gas, which yielded zero publications. Due to the lack of scientific evidence, it is impossible to draw conclusions of the mental effect of using tear gas to disrupt protests. There is only one mention of the extent of harm to the psyche post use of tear gas. A group from the University of California, Berkeley conducted a meta-analysis paper reviewing the safety and efficacy of using chemical irritants in crowd control. In that manuscript, Haar et al., reviewed 31 manuscripts. They reported of the individuals presented in the research study, 5910 people were exposed to chemical irritants and sought medical attention, of whom 5131 (87%) suffered injuries or died as a result of the exposure. Of those, fifty-eight experienced permanent disability. Of those fifty-eight, fourteen reported persistent psychiatry symptoms (Haar et al., 2017).

Of major concern, is the U.S is in the midst of a mental health crisis exacerbated by COVID-19. Currently, there have been worldwide reports demonstrating an increase in people seeking mental health services and experiencing mental health crises as a result of COVID-19. Some of the mental health symptoms reported are increases in stress, anxiety, depression, insomnia, denial, suicidal ideation, fear, grief and loss as result of the economic devastation and isolation from social distancing (Torales, J.,et al., 2020). For instance, in China the prevalence rate of traumatic stress was at an alarming 73.4%, depression was at 50.7%, generalized anxiety was at 44.7%, and insomnia was at 36.1% (Lee, S., 2020). Kaiser Family Foundation found that people in the U.S. reported that 45% of adults reported the COVID-19 pandemic is harming their mental health, and 19% reported it had a “major impact on their mental health” (Kirzinger, A., et al., 2020). Portland’s Police Chief Jami Resch reports calls for threats or attempts of suicide were up 41% in March, 2020 10 days prior to the state of emergency compared to last year (KATU, 2020).

The use of tear gas will exacerbate and further compromise the mental health and stability of protestors on the frontlines fighting for justice. The physical symptoms of tear gas often result in disorientation and agitation, putting someone in a state of fear, anxiety, and panic. Panic attacks often accompany the physical pain one experiences when being tear gassed causing them to experience trauma. Also, being involved in protest whether they are peaceful or not has an effect on the protestor's mental health and wellbeing (Ni, M., et al., 2020). Proximity to violence during a protest is the main predictors of depression in people who are protesting (Ni, M., et al., 2020). Also, when protestors do not come in direct contact with tear gas, being in close proximity and witnessing this violence take place can have a negative effect on their mental health (Ni, M., et al., 2020). In some cases, witnessing someone being tear gassed or having prolonged/repeated exposure to tear gas can lead to symptoms of post-traumatic stress disorder (PTSD). The prevalence of PTSD ranged from 4% to 41% and the prevalence of major depression increased by 7% in areas affected by riots and protest (Ni, M., et al., 2020). Furthermore, depressive Disorder, PTSD, and anxiety disorders/symptoms were the most common mental health outcomes that individuals were diagnosed and treated in an outpatient setting after participating in riots/protest were assessed (Ni, M., et al., 2020). Other outcomes included psychiatric admission and medication, complaints of psychological distress, substance abuse and suicide (Ni, M., et al., 2020).

Balancing Inequities & Public Interests

Use of Tear Gas increases Social Inequities

As it relates to this study, balancing inequities is the use of excessive force (RCAs) as weapons towards communities to strike fear. The use of tear gas as a weapon against peaceful protestors exacerbates existing systemic inequalities and prevents First Amendment right to free speech as well as peaceful assembly (Haar, R. J., et al., 2017) which is excessively cruel to the community. As of June 20th, 2020 there have been 24 consecutive days/nights (Harbarger, M., 2020) of protests that have occurred in Portland, Oregon. In 17 out of 24 protest nights, the Portland Police Bureau (PPB) used excessive force by employing tear gas, rubber bullets, and long range acoustic devices targeted towards peaceful protestors. The unbalanced use of excessive force is seen from reports demonstrating the use of tear gas has been used at a higher rate within Black Lives Matter protests than white supremacy or Proud Boy marches (Kavanaugh, S.D, 2019).

Furthermore, the use of RCAs proves especially dangerous for the most-vulnerable communities (pregnant individuals, unhoused, and companion animals). Accessibility for most protests is still centered on able-bodied people disregarding the disability rights. While PPB often warns protesters before deploying tear gas over loudspeakers, this proves inaccessible for disabled people since PPB does not have sign language interpreters, guides for the blind, or exit routes for the limbless. When it comes to crowd control, such tactics are universally deployed, proving especially dangerous for these vulnerable populations. This is echoed by a quote from Occupying Disability: Critical Approaches to Community, Justice and Decolonizing Disability, “Everytime I go down to Oscar Grant Plaza now, I weigh the risks I take on as a disabled person who can’t run away, a person who can’t cover my mouth or my eyes if they tear gas me. And this makes me furious because I have just as much right to use my voice to dissent as anyone else”.

Animals

Although RCAs are used to assert force on humans, animals are particularly at risk when in contact with these chemicals. A 1971 study exposing eight dogs to CS proved to alter the respiratory pattern, resulting in tachycardia, and increased femoral artery blood flow (Cucinell et. al., 1971). Another group from that same 1971 study proved fatal for some dogs. Two died after being exposed to CS for 23 minutes, died from respiratory distress within three days of the experiments. Of note, Portland Police Bureau maintains eight dogs as part of their special canine (K9) unit. Portland is also home to one of the highest per-capita pet-ownership rates in the nation, backed by its impressive 33 dog parks. Following protests in Hong Kong, one nearby veterinary clinic described having to relocate all the pets as the police’s tear gas seeped into the building causing one cat to begin clawing its own eyes, drawing blood (South China Morning Post, 2019). This pattern of excessive force on animals highlights that the gas is indiscriminate in the affliction of side effects and should be banned due to its public health threat towards pets.

Pattern of excessive force by law enforcement

The City of Portland enforcement leaders such as the Mayor, PPB Chief, and Oregon’s U.S. Federal Judge has publicly acknowledged that racial inequities exist, but has failed to address the harm impacted upon the community by the use of tear gas. Ted Wheeler, the Mayor of Portland, Oregon, stated on June 5, 2020, the use of tear gas against protesters is "ugly," and admitted he agrees with activists who want the police to stop using tear gas (Mimica, M., 2020). The PPB Deputy, Chief Chris Davis, did not affirm the instances in which tear gas was unlawfully used against protestors, and as a result, a federal judge placed formal restrictive guidelines on the PPB’s ability to use tear gas on protesters, citing evidence officers have used excessive force in scattering recent demonstrations. Also, the U.S. Federal Judge that issued a 14 day restraining order against the PPB explicitly stated that Portland police must restrict their use of tear gas, and it should only be used in a situation where the lives or safety of the public are at risk. Following this ruling on June 9, 2020 the tear gas continued.

Through reviewing the most recent attacks on protestors by PPB, there are clear patterns of excessive use of force detailed below.

Mason Lake, a professional photographer, was struck on **May 31, 2020**, by a projectile in the arm, breaking his skin, causing swelling and loss of feeling, according to his lawsuit filed Saturday, June 13, 2020 (OJD 20CV19838, 2020).

On **June 2, 2020**, Philip Elias was struck in the arm and abdomen, leaving rings of severe dark bruising on his body, according to his lawsuit filed Friday, June 12, 2020 (OJD 20CV19783, 2020).

Andrew and Samira Green (pregnant) claim they were frightened for their lives after they went to a protest on **June 2, 2020**, with their children. After police announced the gathering was an unlawful assembly, the Greens attempted to depart but were trapped in a cloud of tear gas, causing them to cough heavily and Samira Green to vomit. (OJD 20CV19978, 2020).

Brandon Farley came forward stating that the officers intentionally shot him in the knee with a rubber bullet on **June 4**, **2020** prompting a visit to the hospital (OJD 20CV19839, 2020)

On **June 5, 2020,** Don't Shoot Portland on behalf of two protesters, Nicholas Roberts and Michelle "Misha" Belden filed the first federal court lawsuit stating tear gas was an excessive use of force and filed a restraining order against the City of Portland.

Julia Leggett claims she was peacefully protesting on **June 5, 2020**, when police shot a flash-bang grenade at her leg -- shredding her pants and causing painful bruising and wounds that have become infected (OJD 20CV19842, 2020).

Lydia Fuller, stated that on **June 7, 2020**, the PPB opened fire on her with military-style weapons including chemical weapons and explosive devices. She was directly hit by a rubber bullet in the chest, which caused bruising to one of her breasts and prompted her to go to the emergency room, according to her lawsuit (OJD 20CV20062, 2020).

Daniel Michaels stated he was retrieving a friend from a peaceful protest on **June 6, 2020**, when police intentionally launched projectiles into his leg, rear, and hand (OJD 20CV19840, 2020).

On **June 9, 2020**, Andrew Tolman, deaf rights activist of Fingerscrossed Interpreting, reported that as he signed to Philip Wolfe, deaf rights activist, the PPB administered tear gas without adequately providing timely announcement for proper communication translation for the deaf and deaf blind community to properly evacuate the area (Allison, M., 2020).

As of **June 14, 2020**, there are a total of 8 lawsuits alleging the use of tear gas on peaceful protestors in Portland, Oregon (Green, A., 2020).

This pattern of excessive force towards humans portrays that there is a gap in knowledge as it relates to when it is considered life threatening to use tear gas. Currently, all instances where the tear gas was dispersed was within a peaceful assembly which should not require putting the public's health at risk.

<u>Conclusion</u>

The U.S. has failed to address the concerns of police brutality that continues to plague our nation. Following the continued killings of innocent Black and Brown lives (**Figure 8**), such as George Floyd, Breonna Taylor, and Ahmaud Arbery, sparked unprecedented protests throughout the U.S. and around the world (**Figure 2**). From this outcry, historic hashtags were birthed such as, #BlackLivesMatter, #SayTheirNames, #DontShootPDX, and #HandsUp, which has been used to connect individuals and organizations in solidarity against police brutality and excessive use of force by law enforcement. As of June 17, 2020, 100 protests calling for justice for Geoge Floyd, Breonna Taylor, and Ahmaud Arbery, were disrupted by the use of RCAs, such as tear gases (**Figure 3**) (Lai, K.K. et al, 2020). The risk of its use is a public health threat and has long lasting health and ecological effects, can result in severe injury, and mental distress, presenting as PTSD and anxiety disorders. Consequently, the use of tear gas to disrupt protests are harmful to the lives of all.

RCAs, such as tear gas, prior to dispersion are converted from solid to a gas using numerous toxic chemicals, which are highly toxic to humans and the environment. According to the MSDS, these chemicals are carcinogenic, toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment, and can lead to conjunctivitis, permanent corneal opacification, convulsions, tachycardia, dyspnea, acute pulmonary edema, asphyxia, chemical pneumonitis, and upper airway obstruction caused by edema, RDA, and death. Additionally, the inhalation of ROC agents exacerbates underlying pulmonary disease such as asthma, emphysema, or bronchitis.

Additionally, there is heightened concern regarding the spread of COVID-19. According to the CDC and WHO, the COVID-19 virus is primarily transmitted between people through respiratory droplets, which are produced in high frequency due to exposure of tear gas since it elicits coughing and sneezing in exposed individuals (WHO, Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations, 2020). This is of grave concern since at least 100 protests have been disrupted by the use of tear gas in recent weeks (**Figure 3**). This is alarming, especially since coughing and sneezing produce greater quantities of respiratory particles that travel further due to the velocity of expulsion from the nose or mouth (Thomas R.J., 2013; Duguid J. P., 1945; Loudon R.G., and Roberts R.M., 1967; Zhou B., et al., 2005). It is also important to stress that RCA weapons are designed to aerosolize tear gas into microencapsulated aerosols ranging from 3 to 10 μm which is in the range of the droplets particles, sized >5-10 μm in diameter, that can transmit COVID-19.

The connections between the use of tear gas and mental health were inconclusive due to the limited research on this topic. Even though there is a huge gap in knowledge on the effects of mental distress following protests and excessive use of force, there are a few manuscripts that shed some light. It is reported that participating in protests, whether they are peaceful or violent, has an effect on the protestor's mental health and wellbeing (Ni, M., et al., 2020). For example, witnessing someone being tear gassed or having prolonged/repeated exposure to tear gas can lead to diagnosis and treatment for PTSD, depressive disorder, and anxiety disorders/symptoms, psychiatric admission and medication, substance abuse, and suicide (Ni, M., et al., 2020).

Although acknowledged by local and national governments that the use of tear gas should be banned, however, there are no current laws to end its use. The local Portland, Oregon Mayor, Deputy Police Chief and Oregon US Federal Judge agree that the use of tear gas should be replaced with an alternative method. Due to the variability in dosing, is it difficult to create safety measures for the use of tear gas in the general public. This adds to the complexity of the conversion of the efficacy of the use of RCAs to disrupt protests. It is difficult to assess what levels will produce irreparable harm or lethal outcomes for the public and environment. This is further exacerbated by multiple grenades and/or canisters being released simultaneously in a specific area within a small time frame, as well as in locations deemed impossible to quickly escape. In addition, there are not any governing bodies to assure the Police's use of the toxic gases and rubber bullet forces are accurate and balanced in the fairness of use as it relates to when these RCA weapons are deployed on gatherings. The local government expresses that they will only use tear gas in life threatening situations, however the patterns of use of excessive force via tear gas can be seen through the amount of witnesses that are sharing their stories with the courts.It is evidence that due to the lack of standardizing a SOP for the deploying tear gas by legal authorities to avoid adverse effects to the public and surrounding ecological system, the use of RCAs such as tear gas should be banned from use.

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