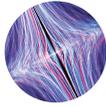


COMMENT

ASTROPHYSICS A history of the useful many-worlds theory **p.30**



HISTORY New biography of the father of dark matter, Fritz Zwicky **p.32**

DATA Research participants' anonymity must be sacrosanct **p.34**

DIVERSITY Promote science in India's minority languages **p.34**

ANTHONY KWAN/GETTY



Police fire tear gas to clear protesters during a demonstration in Hong Kong in August 2019.

Restrict use of riot-control chemicals

Tear gas and pepper spray put lives at risk. Examine their effects and regulate their deployment, urges **Dan Kaszeta**.

In the past few months, tear gas and pepper spray have been deployed to break up street protests in Hong Kong, Gaza, Paris and on the US–Mexico border. Police forces use these riot-control chemicals to clear crowds or to stop fighting. In theory, exposure should be minimal — a group should disperse within minutes to avoid the gas.

The line between civilian and military applications of these chemical agents is

a fine one. Rules governing their use are confused. Reference books and training materials continue to cite toxicology studies from the 1950s. And those were done on animals and soldiers, not the public.

The chemicals involved are mainly CS (2-chlorobenzalmalononitrile, the primary component of tear gas) and OC (oleoresin capsicum, a chilli-pepper extract used in pepper spray). Tear gases were developed

to harass the enemy or to clear bunkers and tunnels in conflicts such as the Vietnam War, as alternatives to deadly force. Pepper sprays came into use in the 1980s for police and self-defence use after being developed as an animal repellent in the 1960s.

Effects vary from person to person. They range from irritation to permanent injury and death. Occasionally, people are exposed to dangerous levels. Authorities ▶

▶ might miscalculate how much agent to use. Someone with an injury or disability, or who is under restraint, might be unable to flee. This variation is not being considered when agents are used in the street.

For example, a 2016 review of the medical literature¹ by Physicians for Human Rights identified 5,131 people from 31 studies who had been injured by riot-control chemicals. Two of these were killed: one from respiratory problems caused by CS exposure; the other after being hit on the head by a tear-gas projectile. Another 70 people (1.7%) developed permanent disabilities, including blindness.

To minimize deaths and serious injuries, researchers and policymakers must work together to expand the evidence base and design guidelines for when and how to use riot-control agents. Stricter reporting and restrictions on use would allow these valuable tools to be deployed as they are intended: to fight violence and crime while keeping the public safe.

IN A FOG

What are these chemicals? Most 'tear gases' are solid powders, delivered in sprays or bursts from canisters. CS is often combined with a flammable filler and spreads as smoke from burning grenades. Sometimes, it is dissolved in a solvent such as methylene chloride. Clouds of acrid fog or smoke drive people to leave buildings or large areas.

CS irritates the skin and eyes and has a distinct peppery smell. It is commonly also used to prepare soldiers for potential exposure to more-dangerous nuclear, biological and chemical agents. It is possible to develop a tolerance to the effects of CS.

The OC in pepper spray comes from

the chilli pepper (*Capsicum annuum*). Strengths vary greatly, so it is usually diluted and sprayed directly at a person or group. It can be extremely irritating, to the point of incapacitation, through intense burning sensations on contact with skin, eyes and the respiratory tract.

A handful of other sprays used in the 1950s, such as CN (phenacyl chloride) and CR (dibenzoxazepine), are still deployed today, although they are widely considered obsolete. CN is marketed (often as 'mace') in the United States as a self-defence spray.

Egyptian security forces allegedly used CR against anti-government protesters in 2011. Adamsite (diphenylaminechlorarsine) and DC (diphenylcyanoarsine) were also once used in munitions. And in Venezuelan riots in 2013, local police allegedly used old stocks of adamsite that were perhaps left over from US military aid delivered in the 1960s.

These alternatives have a narrower margin of safety than do CS and OC. Also, old munitions degrade into toxic by-products that are unpredictable and poorly studied. Security forces might use more grenades or shells if the munitions don't seem to be working as expected, increasing risks.

HEALTH IMPACTS

CS and the older agents (such as CN and adamsite) are said to have low toxicity; it takes a very high dose to kill a person. But these estimates are largely extrapolated from tests in the 1950s and 1960s on laboratory animals². The toxicity of CS was described in this journal nearly 50 years ago³. Human studies

“Governments need to reconsider how they use riot-control agents.”

tended to be limited to healthy male volunteers. This demographic might have been broadly true then for street-gang members, bank robbers and military personnel, but it is not typical of protesters today.

A crowd is likely to contain people with many different vulnerabilities, such as heart conditions or asthma and other respiratory problems. A cloud of CS could drift the wrong way and affect people who are not the target. People unrelated to a disturbance can be caught up in it by mistake.

Nobody knows how much CS or OC is lethal to someone with asthma or the lung disease emphysema, or to a person who needs therapeutic oxygen. It is likely that respiratory conditions will be aggravated, although the research literature is equivocal. In training environments, people who wear contact lenses have told me that these heighten pain when they get OC droplets or CS particles in their eyes.

The effects on children, pregnant women and older people are poorly studied. An analysis after the 2013 Gezi Park civil disturbances in Turkey found women to be more seriously affected by the respiratory effects of CS than men were⁴. No mechanism was established.

And there are many more safety issues to consider. Projectiles containing agents can cause head injuries⁵. The hot, burning canisters in which CS is often dispensed can burn the skin and start fires. Rioters might be exposed to solvents and toxic by-products from burning munitions⁶. Contaminants might be found in poorly made agents, sometimes encountered in the developing world, or in those that are well past their use-by date. None of these factors has been adequately explored.

The parlous state of research in this area stems from many factors. Lab-based testing of people, particularly vulnerable individuals, is likely to be unsafe and unethical. Old data involving prisoners might be questionable. Much field data potentially exist, but gathering them would require identifying people who were involved in civil disturbances. Such individuals might not make themselves available for study, particularly in countries with oppressive regimes or ongoing unrest.

LAX LAWS

The use of riot-control agents for enforcing domestic law is explicitly permitted by the 1997 Chemical Weapons Convention. Applications in warfare are not. There is no ban on producing or stockpiling these agents. Signatories to the treaty (comprising most countries in the world) are required to declare stocks. There is no international framework for controlling export and trade in these substances. Nor is there a reporting mechanism for instances of use.

The use of these agents is thus a matter for national laws. But governments specify



Tear gas is used to disperse an environmental protest in Istanbul's Taksim Square in 2013.



US Navy recruits test their protective equipment before entering a gas chamber as part of their training.

few legal prohibitions, other than through generic laws on police misconduct. Major exporters of the chemicals, such as the United States, tend to have few legal restrictions. The United Kingdom prohibits import, possession or use for personal defence by private citizens. Unsurprisingly, countries with few safeguards on policing, such as China and Turkey, have seen more-widespread uses of tear gas in recent years.

Riot-control agents are often misrepresented in the media. Reports sometimes refer to CS incorrectly as a nerve agent or confuse it with mustard gas or Agent Orange. Some commentators are quick to point out that riot-control agents are banned by a treaty or represent 'war crimes'. They are not, and do not. This misrepresentation can escalate violence. People who think that nerve agents are being used against them might think that they need to resort to lethal force.

CAREFUL CONSIDERATION

Governments need to reconsider how they use riot-control agents. Members of the public deserve protection from injury.

When personnel who have had effective training deploy these substances, they can be a valid alternative to batons, tasers or guns in one-on-one situations. Batons often cause fractures⁷; tasers can cause cardiac arrests. And tear gas and pepper spray might

have some utility in a prison yard.

But more-widespread use, such as lobbing them indiscriminately into demonstrations, needs careful examination. The risks of death, injury or property damage cannot be ignored. The effects of any chemical weapon are inherently unpredictable; history is full of examples of 'friendly' casualties caused by agents carried on shifting winds.

Vast clouds of gas can also be counter-productive. Causing death or injury often escalates, rather than diffuses, a situation.

WHAT NEXT?

Researchers should gather more data about the toxicity of riot-control agents on people other than healthy young men, including women and those with underlying health conditions. Efforts must be made to engage with and study victims of exposure in ways that do not compromise their safety. A better understanding of risks could provide potent evidence to justify increased regulation.

Policymakers and law enforcers should prepare guidelines for best practices and uses of these agents. A good start would be a code of conduct. This should be backed up by legal frameworks that require those wishing to purchase the agents to adhere to the code. Hard projectiles and canisters that burn could be banned or at least restricted to particular situations, such as prison riots or cases in which lethal force has already

been used. Training should be increased.

The Chemical Weapons Convention could be amended to include stronger provisions for riot-control agents. The Organisation for the Prohibition of Chemical Weapons has the framework and infrastructure for such work because it polices other chemical weapons. Riot-control agents should be on the agenda at the organization's meeting in November. ■

Dan Kaszeta is an independent consultant on chemical, biological, radiological and nuclear defence, and founder and managing director of Strongpoint Security in London. He has worked for the US Army and the Department of Defense, has advised the White House and is writing a book on the history of nerve agents.

e-mail: director@strongpointsecurity.co.uk

1. Haar, R. J. & Iacopino, V. *Lethal in Disguise: The Health Consequences of Crowd-Control Weapons* (Physicians for Human Rights, 2016).
2. National Research Council. *Acute Exposure Guideline Levels for Selected Airborne Chemicals* Vol. 16 (National Academies Press, 2014).
3. Jones, G. R. N. *Nature* **235**, 257–261 (1972).
4. Dagli, E. *et al. Am. J. Respir. Crit. Care Med.* **189**, A5775 (2014).
5. Clarot, F. *et al. Forensic Sci. Int.* **137**, 45–51 (2003).
6. Kluchinsky, T. A., Savage, P. B., Sheely, M. V., Thomas, R. J. & Smith, P. A. *J. Microcolumn Sep.* **13**, 186–190 (2001).
7. MacIntosh, A. R. & Desmoulin, G. *T. Appl. Ergon.* **75**, 178–183 (2019).