

Review of Risks of Dual-use Chemicals

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Abstract— Dual-use chemicals are compounds with valid uses in industry, agriculture, or medicine, which can also be misused for malevolent ends such as the production of chemical weapons and drug manufacturing. The dual-use character of these chemicals presents major challenges for global security, public health, and regulatory systems. The article addresses the risks of dual-use chemicals, including proliferation, terrorism, inadvertent release, and environmental contamination. It also reflects on international initiatives in order to control these threats, along with the CWC and national control measures.

Dual-use chemicals, which can serve legitimate purposes for industry, medicine, and agriculture, can also be misused in the development of chemical weapons or for illicit purposes; therefore, their presence raises significant security and ethical issues around the world. The security and ethical issues raised by dual-use chemicals stem from their availability, a relative ease with which they could be repurposed for malicious purposes, and a lack of adequate regulatory control. Major areas of concern are their use in terrorism, warfare, and clandestine production of toxic agents. The trends of globalized production and distribution of chemicals, coupled with improved technological advances in chemical synthesis, distribution, and detection, will make regulating and monitoring dual-use chemicals even more difficult. Mitigating the risks posed by dual use chemicals will require multi-level approaches including effective treaty regimes such as the Chemical Weapons Convention (CWC), regulations and frameworks at the national level, compliance of the chemical industry, and ongoing vigilance and vigilance by scientists and the international community to limit dual-use misuse while maximizing safe dual-use beneficial uses of chemicals. The dual-use issue raises critical issues of how scientific development and innovation can simultaneously ensure global security and ethical responsibility.

Keywords — Chemical munitions, Dual use chemicals, Risks of chemicals.

INTRODUCTION

Dual-use chemicals are chemicals that can be legitimately used in legal civilian activities, but which may also be misused

for purposes prohibited under the Convention, categorizing the classification between legal and illegal uses of the chemical. There are now 68 featured chemicals that have continued applications in agriculture, pharmaceutical and manufacturing industries, however the use of these chemicals to nefarious uses poses two-fold the damage to both public health, security and stability on a global level (1).

Dual-use chemicals refer to chemicals which can be lawfully use for legitimate civilian use, but can be misused for purposes prohibited under the Convention, identifying the distinction of the legal and illegal use of the chemical. Currently there are listed 68 featured chemicals with persistent uses in agriculture, pharmaceuticals, and manufacturing sectors, nevertheless the use of their current chemical compounds to harmful uses brings twice the harm to the public health, security, and stability in a global scope (1).

This review outlines regulatory barriers, security concerns, and possible migratory pathways. The study identifies gaps in current policies existing guidelines, and the emerging threats from these chemicals through examination; and calls for better oversight, greater public awareness of the risk, and global partnerships to minimize the risk from these chemicals.

Chemical weapons are also dual-use materials. This makes their boundary very hard to police; they are accessible for potential misuse and are marketed actively awaiting enforcement of prohibited use, they have the potential to be released inadvertently, they can also be misused intentionally, and their production and use are all very difficult to monitor. International agreements, such as the Chemical Weapons Convention (CWC), aim to more strictly control the availability of hazardous chemicals to limit abuse. The increase of chemical synthesis and access to feedstock and global supply chains has increased awareness of their dual-use potential (2).

The nature of dual-use chemicals is in a challenging space between useful application and potential misapplication. These substances are vital for pharmaceuticals, agriculture and manufacturing; however, the potential for harmful use have created interest and concern from the government and international organizations. Better understanding of dual-use chemicals will help formulate regulations and operations aimed at limiting the risks posed by dual-use chemicals. Dual-use chemicals are materials that can be used for civilian and military purposes. Chlorine, although we use it in killing pathogens in drinking water, can also be a chemical weapon. Thiodiglycol is both a precursor for dyes and a precursor for mustard gas. The

ambiguity of these chemicals is also what complicates regulations and detection of misuse (3). the risks of dual-use chemicals include (3):

- 1- Proliferation and Weaponization One of the more critical risks stems from state or non-state actors procuring dual-use chemicals in an effort to develop chemical weapons. The ease of access to many dual-use chemicals through legal commercial procurement makes them attractive for clandestine operations.
- 2- Terrorism Terrorist groups have used dual-use chemicals, including the sarin attack on the Tokyo subway system in 1995. The wide availability of dual-use chemicals and their ability to create mass destruction make them a favourable option for asymmetric warfare.
- 3- Accidental Exposure Accidental release of dual-use chemicals can happen through improper storage, handling, and transport, creating a danger to health and environment.
- 4- Environmental Damage Spills or accidental releases of dual-use chemicals can contaminate air, water, and soil, with long-term ecological consequences with regard to food and water security.

Dual-use chemicals are necessary in many sectors and allow society to grow and progress, their potential for nefarious uses poses a serious risk to public health and safety, as well as global security. Global cooperation and oversight is necessary to manage such risk, and create robust regulations, and constant vigilance by the scientific community and security agencies. International regulatory frameworks include (4)

- 1- Chemical Weapons Convention (CWC) The CWC is a multilateral treaty that prohibits the production and use of chemical weapons and requires the destruction of existing stockpiles. The CWC places chemicals into a series of Schedules in relation to their potential for misuse, and requires declarations and inspections.
- 2- National Legislation and Export Controls Countries have to set domestic laws & export controls to try to keep the trade and use of dual-use chemicals to a minimum level (i.e., to control chemicals). Domestic legislation includes things such as licensing systems, end-user verification, and penalties for non-compliance. While some dual-use chemicals may be used legitimately, they can also be used to manufacture harmful agents and are associated with many security, ethics and regulatory issues. Dual-use chemicals are both critically important for many applications of legitimate use, including industrial processes and agriculture, and non-legitimate use including the manufacture of chemical weapons and synthesis of illicit drugs, especially with the developments in synthetic chemistry and biotechnology. It is easier to access side dual-use chemicals, and with the globalization of imports of chemicals, it is impossible to track imports.

The threats associated with dual-use chemicals can span the spectrum of inadvertent exposure by industrial accident to intentional abuse. Hypothetical agents that could pose potential psychotropic effects could be not just the precursors of nerve agents like sarin but also VX, since there is substantial use of the precursors in pesticides, thus facilitating any potential weaponization (5). There has undoubtedly been abuse of chemicals such as ammonium nitrate, which is critical to fertilizers, in explosives, posing major challenges regarding

determining how to not issue blanket criminalization of a material that could play a role in economic utility but is also capable of creating security threats (6). The ways these risks can be confronted are on several policy fronts, as this has been approached by governments and international stakeholders, e.g., structures built in association with the Organisation for the Prohibition of Chemical Weapons for enforcement, monitoring and international cooperation gaps. It considers risk associated with dual-use chemicals, reflects upon abuse cases, as well as evaluates the regulatory space needed to divert such chemicals from improper use (2).

Some of these dual-use chemicals have valid uses for civilian purposes but also have potential for diversion to use in the production of chemical weapons or in criminal activity. Although dual-use chemicals are commonplace in agriculture, pharmaceuticals, and manufacturing, diversion to a nefarious purposes harms public health, public safety and international security and stability (7).

As technologies and chemicals spread globally, supply chains are increasingly getting globalized and with this come new understandable threats of biochemical weapons due to the synthesis of biological products. Household common morphology discoveries of chemicals being diverted as explosives and drugs too (8). The main concerns associated with the dual-use chemicals consist of:

- 1- Proliferation of Chemical Weapons — Use of industrial chemicals for war or terrorism, e.g., sarin gas attacks (2).
- 2- Explosive manufacture: (fertilizer-based Explosive – For large where large bombings have previously been made reference to (9).
- 3- Pseudoephedrine and other pharmaceutical precursors are commonly diverted for (meth) steroid use (10).
- 4- Emerging Biochemical Threats advances in synthetic biology could create new toxic agents. To mitigate this issues, international regulatory mechanisms (e.g., Chemical Weapons Convention (CWC) and monitoring mechanisms (e.g., Australia Group) exist to balance the need to prevent misuse of a substance with the need to have legitimate access to key chemicals, but enforcement, getting cutting-edge technology, and balancing security with scientific achievement is still hard.” Chemicals that have legitimate uses in industry, agriculture, or medicine, but can also be divested to illicit means — including chemical weapons or illegal drugs — are referred to as dual-use chemicals. This duality presents challenges for ensuring the beneficial uses of this technology do not also have adverse security consequences (7,11).

Some to some other dual use chemicals are on the list of contaminants of emerging concern, mainly because they will not break down potentially for some time creating uncertainty around their adverse health impacts. Per- and polyfluoroalkyl substances (PFAS), that are typically used for their grease and water repellent properties, are for instance, extremely stable and do not break down or decompose readily in nature. These "forever chemicals" can be measured in various environmental matrices (human samples, etc.). Potential adverse health impacts linked to PFAS exposure have been connected to high cholesterol; kidney and thyroid function; immune suppression; and certain cancers. Other dual use chemicals like

organophosphate pesticides (that are ubiquitous throughout all agricultural systems) decompose readily in the environment, however research studies have pointed out that they may damage energy absorption, growth of crops, and in fact have wider implications for soil fertility and additionally cause respiratory stress, behaviour changes, and delay in metamorphosis in aquatic organisms (12).

Many of the dual-use chemicals are endocrine disruptors, changing hormones within both animals and humans. EDCs (endocrine disrupting compound) such as bisphenol A (BPA) (found in many plastics), and certain sprays and pesticides have been shown to mimic, or inhibit hormone activity; resulting in reproductive harm, developmental interference, and cancer risk (11). BPA-free products have been shown to leach EDCs, ultimately raising caution regarding certain alternative compounds, like bisphenol S (BPS) and bisphenol F (BPF), that have been substituted for BPA (13).

Some examples of dual-use chemicals include

1- Chemical weapon precursors - thiody glycol (can be used for mustard gas), and methyl phosphonyl difluoride (can be used for sarin (5)).

2- Explosive precursors - ammonium nitrate and hydrogen peroxide (being reformulated for IEDs (6)).

3- Pharmaceutical precursors - Ephedrine and pseudoephedrine for methamphetamine production (12).

These compounds are controlled and monitored by international bodies, for example: The Organisation for the Prohibition of Chemical Weapons, their goal is to inhibit the unauthorized use, while allowing acceptable industrial and medicinal use (2).

The greatest risk is the potential for dual-use chemicals to be weaponized in chemical warfare and terrorism. Past instances have demonstrated the potential for Weaponization of dual-use chemicals. Non-state actors, special interest groups, and terrorist groups have exploited deficiencies and inconsistencies with regulatory controls to obtain precursors for nerve agents and toxic industrial chemicals (4,13). There are also unintended risks for dual-use chemicals for accidental exposures and environmental contamination. For example, the Bhopal disaster (the toxic gas leak of methyl isocyanate) in 1984 occurred partly due to incorrect handling and lack of regulations. Potentially improper disposal of dual-use chemicals can also impact groundwater and pose health risks from potential or inadequate cleaned-up chemical contamination (12,14).

The review aims to analyse the dual-use risks of chemical and look at the issues of regulation, security issues, and mitigation strategies related to the dual-use risks. By calling out the known and the emerging threats by reviewing recent policy, the uninformed risks of those chemicals, and existing chemical and industrial incidents, this study advocates for increased oversight and awareness, and international cooperation to manage the risks associated with dual-use chemicals.

CONCLUSION

Dual-use chemicals can be essential for society and modern industry but pose serious risks when misused. Strategies to balance innovation and security must be inclusive, flexible, and cooperative. If the international community strengthens global norms, increases regulatory mechanisms, and promotes an

accountability culture, we will be better able to manage the dual-use dilemma.

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