Chapter 17

Prevention of CBRN Materials and Substances Getting into the Hands of Terrorists

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Chemical, Biological, Radiological and Nuclear (CBRN) threats are ranked very high on the list of near future threats due to their expected extraordinary impact on societies affected. After the 9/11 attacks that raised the terrorism concerns to a new level, many security experts believed that a CBRN attack was only a matter of time ("when, not if"). The fact that the world has not experienced a major CBRN incident from non-state actors since then does not mean that terrorists are not pursuing the acquisition of hazardous materials, namely chemical weapons, biological agents or nuclear and radiological materials to be deployed with or without the use of explosives. Therefore, it is imperative to prevent CBRN materials and substances getting into terrorists' hands. In order to do this, we need to explore and map all the sources and pathways for terrorists to achieve their goals, so we can better provide assistance, guidance, support, and technical expertise to relevant actors. This chapter will focus on prevention and will try to uncover existing gaps, thereby facilitating possible solutions and develop countermeasures that will lead to better control of CBRN agents and a more efficient management of a very serious (near) future problem.

Keywords**:** CBRN, materials, substances, agents, dirty bomb, terrorists, smuggling, biological, chemical, radiological, nuclear, Al-Qaeda, ISIS

The modern world faces a number of conventional (natural or man-made) and non-conventional (including asymmetric) threats that range from natural disasters to urban bombings, including the accidental or intentional release of chemical, biological, radiological, or nuclear materials (CBRN), without or with the aid of explosives (CBRNE). Who could be behind some of these threats? Could it be states, terrorist organization or even lone actors?

Two recent developments in particular, have alarmed security agencies worldwide – jihadist plots disrupted before chemical and biological agents were used in a terrorist attack. In the first incident (July 2017) a plot involving a chemical improvised device able to release hydrogen sulfide was discovered in time in Sydney, Australia.[1] A second incident, uncovered in 2018, saw a Tunisian national being prevented from using ricin (84.3 milligrams were confiscated), a highly dangerous biological toxin found in his apartment.[2]

Although CBRNE is synonymous with weapons of mass destruction, the term "destruction" is appropriate in a strict physical sense only to the nuclear element (N) and its potential. Chemical weapons (C), certain Category "B" (biological) agents and radiological (R) dispersal (dirty bombs) or emitting devices might cause "disruption" rather than destruction when released. Destructive impact depends also on the size of the target: attacking a small village can be totally destructive while a same size attack in a major city with a population of 10 million or more would, relatively speaking, not be "destructive" to the same extent. In addition, the magnitude of destruction cannot be defined by the numbers of casualties. It should also be noted that CRNE threats represent acute emergencies, while a bioterrorism attack or a pandemic are gradually developing emergencies that depend on the incubation period of the pathogen, its virulence, toxicity, and related factors.

The complexity and unpredictability of these threats are high. At the moment, many potential CBRN events are of low probability but of potentially very high impact.[3] This is why political leaders are reluctant to take pre-emptive measures; these can have a substantial price tag and there are so many possible targets from critical infrastructures to mass gatherings. Unfortunately, many people forget that the unexpected can happen. The ongoing Covid-19 pandemic is evidence of this.

In addition, the feasibility of CBRN attacks is directly linked to the high number of potential targets. Soft targets, of which there are too many, are, by definition, not prepared to handle a CBRN incident. Therefore, the only viable solution is to invest in prevention measures in an effort to keep CBRN materials and substances out of reach for terrorists. Unfortunately, this is not an easy task to perform; it requires in-depth knowledge of the agents involved, the pathways used in their production and possible acquisition and, most important of all, continuous global exchange of information, since all countries face the same threat, even if some are thought to be preferred targets.

CBRN Materials and Substances

Chemical Weapons

Under the chemical weapons' roof there are original chemical warfare agents, dual use chemicals or precursors, toxic industrial chemicals and the equipment/munitions to be used for the dispersal of these agents both in open fields and in urban environments. Toxic chemical agents are gaseous, liquid, or solid chemical substances causing death or severe harm. Chemical weapons include blister agents, nerve agents, choking agents, and blood agents, as well as non-lethal incapacitating agents and riot-control agents when deliberately used to harm people. Chemical weapons are categorized as:

1. nerve agents like sarin, soman, tabun or VX affecting mainly the nervous system;
2. blister agents (i.e., mustards), mainly affecting the skin;
3. pulmonary agents like phosgene or chlorine damaging the lungs;

4. blood agents like cyanide affecting the oxygenation of the body;
5. tearing and incapacitating agents like mace, CS, CR, or capsaicin used mainly in riot control operations; and
6. psych/mood modifying agents like LSD.

Biological Weapons

Biological weapons are warfare agents that directly or indirectly intentionally affect humans, animals or vegetation. These agents can be disseminated by spraying or by mixing with food/water and can involve viruses, bacteria, prions, toxins or fungi. Biological agents such as these as well as toxins can be turned into weapons delivered in the form of liquid droplets, aerosols, or dry powders. Currently, scientists are concerned that a modern technique called Clustered, Regularly Interspaced, Short Palindromic Repeat (CRISPR) is becoming more widely available, allowing even amateurs to start experimenting. The technique works like genetic scissors, allowing to cut away existing DNA code and replace it with new ones. This new technique is now available in the market place where anybody can buy certain do-it-yourself kits that might cause big problems to public health authorities (e.g., E. coli resistant to antibiotics kits are already for sale on the internet for under £ 100).[4] On the other hand, terrorists with a scientific background or rogue scientists supported by cyber-criminals, might be able to genetically interfere in the genetic code of existing pathogens and transform them into more malicious agents affecting both humans and animals.[5]

While the capabilities of organizations like Al-Qaeda have so far not matched their ambitions, there is little doubt about their motivation to use them chemical and biological weapons. Al-Qaeda's spokesman Abu Gheith stated in 2002:

> "We have the right to kill four million Americans, two million of them children … and cripple them in the hundreds of thousands. Furthermore, it is our obligation to fight them with chemical and biological weapons, to afflict them with the fatal woes that have afflicted Muslims because of their chemical and biological weapons."[6]

Radiological Weapons

Commonly known as "dirty bombs," these weapons use conventional high or low explosives for dispersal as well as other means to spread radioactive material which may lead to short- and long-term health problems of the affected population and cause extended territorial radioactive surface contamination. Radiological weapons do not require nuclear weapon-grade materials; only some radioactive substance of sufficient potency to achieve harmful effects. There are four types of radiological dispersion.

First, a radiological dispersal device (RDD) in the form of a conventional explosive attached to radioactive material ("dirty bomb"). RDD consequences include loss of lives (more from the explosion than the radioactive pollution) psychological shock, business disruption and high decontamination costs. Second, is a silent release of radioactive materials in the air, the water, or on the soil by aerosol, dilution or dusting. Third, is a stationary radiological emission at a place where people reside (Radiological Emission Device – RED: e.g., an uncapped lead container left under the seat of a metro train). Fourth, is an attack on a storage site of radioactive materials resulting in subsequent dispersal – i.e., a waste storage facility or a hospital or the hospital's blood bank using a cesium irradiator.

Some of the most dangerous radioisotopes are: Cobalt-60, Americium-241, Cesium-137, Iridium-192, Plutonium-239 and 238, Strontium-90, Californium-252, Radium-226, and Lead-

103. The half-life of certain radioisotopes is of security concern, such as: Americium-241 (433 years); Californium-252 (2.7 years); Cesium-137 (30 years); Cobalt-60 (5.3 years); Iodine-131 (8.0 days); Iridium-192 (74 days); Polonium-210 (140 days); Plutonium-238 (88 years); Plutonium-239 (24,000 years); Radium-226 (1,600 years); and Strontium-90 (29 years).

Nuclear Weapons

While there are different types of nuclear weapons, all employ nuclear fission or fusion reaction for unfolding their explosive power. Most nuclear weapons today are two-stage thermonuclear weapons that derive their explosive energy from the combined power of nuclear fission and fusion. That is, an initial fission reaction generates high temperatures needed to trigger a secondary – and much more powerful – fusion reaction, hence the term "thermonuclear." Sufficient quantities are required in order to construct an atomic bomb such as Plutonium (Pu-239) – 7-8 kg; Plutonium Oxides (PuO_2) – 10 kg; Metallic Uranium (U-235) – 25 kg; Highly Enriched Uranium Oxide (UO_2) – 35 kg; Intermediately Enriched Uranium Oxides – around 200 kg. In April 2004, Abu Mus'ab al-Zarqawi**,** former leader of Al Qaeda in Iraq, stated "If we had such a nuclear bomb – and we ask God that we have such a bomb soon – we would not hesitate for a moment to strike Israeli towns, such as Eilat, Tel Aviv, and others."[7]

Critical nuclear materials are distributed mainly in one of the ten countries possessing nuclear weapons such as Russia, the US, France, UK and China (~99% of highly enriched uranium) while a small proportion (1%) is spread among 40 countries (including India, Pakistan, North Korea and Israel), in about 100 sites worldwide – in over 130, often ill-protected, research reactors. In addition, there are 250 metrics tons of separated plutonium in military stockpiles and 250 metric tons in civilian stocks, held mostly in Russia, the US, France, Germany, the UK; some in Belgium, China, India, Israel, Japan, North Korea, Pakistan, and Switzerland.[8]

Two nuclear specialists estimated that, for $2 million, a terrorist group could acquire the necessary equipment, personnel, non-fissile material, and transportation support to build a crude nuclear device. For an additional $8 million, they speculated that enough bomb-grade material could be acquired. It is by no means beyond the realm of possibility that a terrorist group of reasonable size would leverage such resources for a nuclear project.[9] Modern terrorist movements like Aum Shinrikyo in the 1990s and later on al Qaeda and ISIS (even after the defeat suffered), had or could have this level of resources at their disposal. On the other hand, it has to be noted that of the 31 countries who at one time were considered developing nuclear weapons, only ten produced a deliverable atomic bomb. Seven countries with a formal nuclear weapons program gave up their attempts.[10]

Explosives

An improvised explosive device (IED) is a type of unconventional explosive weapon that can take any form and be activated in a variety of ways. They target soldiers and civilians alike.[11] In the second Iraq War, IEDs were used extensively against US-led invasion forces and by the end of 2007 they had become responsible for approximately 63% of coalition deaths in Iraq.[12]

They are also used in Afghanistan by insurgent groups. In 2009 alone, there were 7,228 improvised explosive device (IED) attacks in Afghanistan, a 120% increase over 2008, and a record for the war.[13] IEDs can be used to disseminate C/R agents. IEDs cannot be combined with biological agents since the heat produced during detonation might kill most of the pathogens. Weaponized biological warfare agents follow a complex methodology of dispersal sustaining the survivability of the organisms.

Concerns and Vulnerabilities

The situation in certain parts of the world generates concerns and elicit vulnerabilities. In a 1999 article, Alex Schmid noted that some of the conflict zones (e.g., in the Caucasus) host civic nuclear facilities or research institutes that could be used for theft or fabrication of WMD while the civilian nuclear industry produces huge amounts of plutonium which is attractive to thieves. In addition to rogue scientists, organized crime might become involved in the procurement and transport of nuclear materials since concealment and transport of some of these weapons are, due to their small size, relatively easy. On top of the above, urbanization has increased the chance of mass fatalities in the case of an attack.[14]

In the international literature, there are many scenarios exploring a biological or chemical attack eliciting mass casualties. For example, there is the popular scenario of a small airplane (e.g., a crop sprayer) flying over a metropolitan city spraying 50 to 100 kg of anthrax spores, with the potential of killing from 130,000 to 3,000,000 citizens, depending the meteorological conditions.[15] This scenario and a few others are still far beyond the capabilities of modern terrorists even if they have the scientific background to culture *B. anthracis* and create a collection of spores.[16] This scenario is more indicative of a rogue state attack against another country and might result in severe retaliation – e.g., in the form of a nuclear attack.

But the same scenarios can be seriously considered on a much smaller scale focusing on specific targets (i.e., the staff of an embassy) or be used for assassination purposes (e.g., the North Korean VX attack in a Malaysian airport; ricin letters mailed to US officials, etc.). Despite the widespread perception assuming that terrorists are pursuing the acquisition of CBRN agents, a more realistic assessment makes clear that there are certain inhibiting factors that should make even terrorists reluctant to be using weapons of mass destruction even if they may be able to lay their hand on them. In general, there is a:

1. general reluctance to experiment with unfamiliar weapons;
2. lack of familiar precedents;
3. fear that the weapon would harm the producer (i.e., radiation) or user;
4. fear of alienating relevant constituencies and potential supporters on moral grounds;
5. fear of unprecedented governmental crackdown and retaliation targeting them, their constituencies or sponsor states;
6. lack of a perceived need for indiscriminate, high-casualty attacks for furthering goals of the group; and
7. lack of money to buy nuclear material on the black market.[17]

The latter might not be the case, during the period that ISIS was thriving and a significant amount of financial resource was available from a spectrum of sources (e.g., oil smuggling, extortions, kidnapping for ransom, robberies, etc.). It is of note that the 40kg of low-grade uranium stolen from the University of Mosul, Iraq (2014), is still missing. That material is not good enough for assembling a nuclear bomb, but might be used for a radiological dispersal device.[18]

Dual-Use Items of Proliferation Concern

Dual-use goods and technologies refer to those that are capable of, or were designed for, use for peaceful and legitimate civilian or commercial purposes, but also have potential applicability in the development or enhancement of weapons' programs, including WMDs. Dual-use refers not only to certain chemicals (e.g., dimethyl methyl phosphonate, thiodiglycol or arsenic trichloride), but also to certain biological agents with a bioterrorism potential.

The Chemical Weapons Convention requires declarations about, and inspections of, industrial facilities that produce, process or consume more than specified threshold amounts of certain chemicals, dual-use and otherwise.[19] Specific requirements and procedures vary, depending on the risk a chemical substance poses to the object and purpose of the Convention. Based on the degree of this risk and the extent of their commercial application, chemicals are divided into three so-called Schedules, which form an integral part of the Convention. Each of the three Schedules contains lists of toxic chemicals and precursors with corresponding Chemical Abstracts Service (CAS) registry numbers. The Organization for the Prohibition of Chemical Weapons (OPCW) in The Hague maintains a database of approximately 32,000 scheduled chemicals on its website, a small portion of all possible scheduled chemicals. Riot control agents (RCAs), such as tear gas and pepper spray, are not included in any Schedule.

Who is Interested in the Malicious Use of CBRN Agents?

Apart from the military use of CBRN agents by rogue regimes (officially forbidden; the majority of chemical and biological weapons have been destroyed under relevant conventions), terrorists are the second group interested in their acquisition and possible use against soft targets around the globe.

Al Qaeda

In the period before 9/11, al Qaeda made several unsuccessful attempts to obtain radiological and nuclear materials.[20] Despite these failed efforts to acquire the appropriate materials, technology and know-how, Osama bin Laden, stated: "Acquiring chemical and nuclear weapons for the defense of Muslims is a religious duty." (…) Adding: "It is the duty of Muslims to prepare as much force as possible to terrorize the enemies of God." In the same vein, Abu Mus'ab al-Suri[21] stated:

> "…. we are serious about acquiring all possible weapons and means and will deal with you the same way, in accordance with our true religion. (…) Hitting the US with WMD was and is still very complicated. Yet it is possible after all, with Allah's help, and more important than being possible – it is vital." [22]

Al-Suri further stated, "…. if those engaged in *jihad* establish that the evil of the infidels can be repelled only by attacking them with weapons of mass destruction, they may be used even if they annihilate all the infidels."[23]

ISIS

In June 2014, Jama'at al-Tawhid wal-Jihad, a group which previously had pledged allegiance to al-Qaeda, proclaimed itself as a worldwide caliphate and began referring to itself as the 'Islamic State', claiming religious, political and military authority over all Muslims worldwide. The atrocities conducted by this group were beyond the pale of conventional ethics. It was also the first time that terrorists used chemical weapons against their opponents in both Syria and Iraq.[24]

European Jihadists Returning from Syria and Iraq

Since the Syrian conflict began in 2011, thousands of EU nationals and residents have traveled,

or attempted to travel, to conflict zones in Iraq and Syria to join insurgent terrorist groups, such as ISIS. Research conducted in 2016 estimated that the contingent of foreign fighters originating from EU Member States (mostly from Belgium, France, Germany, and the UK) numbered between 3,922 and 4,294 individuals. Of those, it has been estimated that around 30 % had already returned to their home countries by 2016.[25]

Returning jihadists are perceived as a security threat mainly because they have real combat experience and can serve as role models for radicalizing new recruits, raise money for terrorism or even conduct retaliation attacks against targets in their homelands.[26]

A number of returnees have academic and/or professional backgrounds relevant to the science behind CBRN threats. Apart from the real combat experience that they might have gained, some might have been recruited in the inner nucleus of those involved in handling or producing chemical weapons that subsequently were released on the battlefields of Syria and Northern Iraq. Alternatively, they might have been involved in the safe and secret storage for future use of the radioactive material stolen from the University of Mosul in Iraq or they might have been employed in the mass production ammunition and explosives (IEDs) factories operating in the territories under ISIS control until late 2018.

After losing the war on all fronts in Syria and Iraq, most of these European jihadists found themselves to be deprived of a homeland, with limited resources, wanted by local and international coalition forces, and facing the dilemma either to return back to Europe or migrate to another relatively "safe" conflict theatre like the Philippines, Indonesia, Yemen or Afghanistan, etc. The current, "second generation," whose departures were interlinked with the activities of ISIS, is perceived to be "more battle-hardened and ideologically committed," and may have come back with violent motives including to harm EU citizens. Due to their loss of territory, many of them feel angry and some of them may harbor a strong desire to do harm to as many people they are capable of hurting by using their destructive know-how attained abroad. Although most of them are already known to national authorities and are under surveillance they are aware that most states do not have the resources and manpower to follow them 24/7 or to record all their contacts via the social media and dark web.

Various other Actors

After 9/11, a number of CBRN-related plans and plots have been uncovered, including these:

- a plan by US citizen José Padilla (2002: dirty bomb attack in the US);
- the Benchellai's "Chechen Plot" in France (2002) against Russian interests in Europe, involving C or B (probably Ricin);
- the 2003 Bourgass' Ricin poison plot (by using castor beans in London);
- the plot by Indian-born British Dhiren Barot (2004: constructing dirty bombs from smoke detectors containing Americium-241 targeting the New York Stock Exchange, IMF headquarters, and the World Bank by using limousines packed with explosives and radioactive "dirty" bombs);
- the 2007 Iraq attacks with vehicle-borne explosives (VBIEDs) and chlorine gas containers;
- the 2018 Cologne plot orchestrated by the Tunisian Sief Allah H. who was manufacturing an explosive device which incorporated the highly toxic substance Ricin.[27]

There are several cases of CBRN-based attacks that have been carried out or attempted by secular groups. For example, in 1990 the Tamil Tigers (LTTE) stole drums of chlorine gas from a chemical facility and then used these against the Sri Lankan army.[28] There is one important thing that must be understood when it comes to CBRN terrorism. Among the hundreds of violent non-state actors that populate the field of terrorism, only a small percentage

of these are actually willing – for a variety of reasons – to resort to CBRN terrorism. Within this smaller subset of willing groups, an even smaller percentage has the capability to engage in CBRN activities. The difficulties inherent in such an endeavor are well summarized in the experience of the Japanese apocalyptic cult Aum Shinrikyo.[29] Despite its vast resources, expertise, and – as a religious cult – de facto immunity from government interference – Aum fell short of expectation, as the group's sarin gas assault in the Tokyo subway was not able to achieve the level of destruction desired. Identifying those groups that possess both the motivation and the capability is a first step in thwarting the CBRN threat.[30] A number of mechanisms exist which can contribute to fight the proliferation of CBRN technologies.

International Regulation and Control Bodies

There are a number of international instruments meant to control CBRN materials and uses. However, most of these refer to state actors and their proliferation concerns with regard to other state actors.

Treaties and Conventions

There are several important treaties and conventions:

- Nuclear Non-proliferation Treaty (NPT):[31] Prevents the spread of nuclear weapons and weapons technology, to promote cooperation in the peaceful uses of nuclear energy and to further the goal of achieving nuclear disarmament and general and complete disarmament.
- Biological and Toxins Weapons Convention (BWTC):[32] Effectively prohibits the development, production, acquisition, transfer, retention, stockpiling and use of biological and toxin weapons. The convention is a key element in the international community's efforts to address the proliferation of weapons of mass destruction.
- Chemical Weapons Convention (CWC):[33] Aims to eliminate an entire category of weapons of mass destruction by prohibiting the development, production, acquisition, stockpiling, retention, transfer or use of chemical weapons by States Parties.
- Hague Code of Conduct Against Ballistic Missile Proliferation (HCOC):[34] This code of conduct is the result of efforts of the international community to internationally regulate the deployment of ballistic missiles capable of carrying weapons of mass destruction.

Export Control Regime

There are also several important export control regimes:

- The Nuclear Suppliers Group (NSG)/Zangger Committee:[35] This is a group of nuclear supplier countries that seeks to contribute to the non-proliferation of nuclear weapons through the implementation of two sets of Guidelines for nuclear exports and nuclear-related exports.
- The Australia Group (AG):[36] An informal forum of countries which, through the harmonization of export controls, seeks to ensure that exports do not contribute to the development of chemical or biological weapons.
- The Wassenaar Arrangement:[37] This mechanism has been established in order to contribute to regional and international security and stability, by promoting

transparency and greater responsibility in transfers of conventional arms and dual-use goods and technologies, thereby preventing destabilizing accumulations of arms.

- The Missile Technology Control Regime (MTCR):[38] Restricts the proliferation of missiles, complete rocket systems, unmanned airborne vehicles, and related technology for those systems capable of carrying a 500 kg payload at least 300 km, as well as systems intended for the delivery of weapons of mass destruction (WMD).

Emerging Technologies

Technical innovations can weaken control over the illicit use of CBRN agents and materials, but at the same time they can also assist in the prevention of CBRN attacks.

Drones

A drone, in technological terms, is an unmanned aircraft. Drones are more formally known as unmanned aerial vehicles (UAVs) or unmanned aircraft systems (UASs). Essentially, a drone is a flying robot that can be remotely controlled or fly autonomously through software-controlled flight plans in their embedded systems, working in conjunction with onboard sensors and GPS.[39] Drone swarms consist of multiple unmanned platforms and/or weapons deployed to accomplish a shared objective, the platforms and/or weapons autonomously altering their behavior based on communication with one another or with a ground pilot approving (for the time being) firing decisions. The interconnectivity of drone swarms enables them to exhibit more complex behaviors than their component drones. There is a significant distinction between drone swarms and drones *en masse*.[40] Drones *en masse* are the use of multiple drones without autonomous communication between the drones.

Drone-swarm technology is possible to increase/improve delivery of CR agents.[41] The incident with a drone carrying a vial with a radioactive liquid that landed on the roof of the building where the office of the Japanese Prime Minister is, represents an example of future drones' possibilities.[42]

A possible scenario could be based on drones positioned on rooftops programmed to remotely take off at a given time, providing enough time to terrorists to escape the area or the country. In such a scenario the combination of chemical weapons with conventional munitions might trigger panic and chaos since responding to an attack while in personal protective equipment with limited dexterity, vision, and communication is not very effective. In a parallel scenario, a conventional drone attack might mask a simultaneous biological dispersal to a totally unprotected population. It is of note that most cities are not equipped with air defense systems capable to intercept or destroy drones as it was recently witnessed repeatedly times in London's Gatwick and Heathrow airports.[43]

It is worth considering that one or more drones can attack the incident command post supervising a chemical or radiological incident site not to mention their ability to interfere in communications by using sophisticated jamming equipment. The "aerial terrorist" of the future might also coordinate a swarm with a variety of specialized drones that will maximize the deadly consequences of the attack.

Hacking

The threat of cyber-attacks targeting chemical or nuclear facilities is a growing possibility.[44] Given that chemical plants are now largely controlled by the use of networked computers, it is possible in some countries that cyber-attacks similar to the Stuxnet targeting of Iranian nuclear could cause critical systems failure.[45] By hacking into computer networks, an adversary could

reprogram an industrial control system so that it commands the equipment to operate at unsafe speeds or opens valves when these should remain closed.[46]

Critical systems, like those of public utilities, transportation companies, and firms that use hazardous chemicals, need to be made much more secure. One analysis found that only about one-fifth of companies that use computers to control industrial machinery in the US even monitor their equipment to detect potential attacks - and that in 40% of the attacks they did catch, the intruder had been accessing the system for more than a year.[47]

The Internet

When it comes to terrorism, the internet is considered the proverbial Pandora's box. Numerous websites, social media pages, and chat rooms in the world wide web and many more in the dark web provide information and detailed instructions, offer manuals and books about practically everything[48] – from constructing an IED to how to produce ricin from castor beans at home.[49] Not all sources on the internet are reliable but some can lead amateurs to the construction of a real weapon with the help of ingredients available over-the-counter or from suppliers on the internet. Is it possible to control the internet? Unfortunately, it is too late now in open societies – terrorists know that and we know that. What can be done to minimize the spread of malignant knowledge? Existing technologies make identification of internet interactions a very difficult and sometimes impossible task, given encryption and other hiding techniques.

Prevention

To prevent access to CBRNE weapons, government and corporate and other security actors must focus on a number of areas including theft and smuggling; rogue state trade; trafficking; scientist recruitment; orphan sources; the use of toxic industrial chemicals as weapons; dual biotechnologies; dirty bombs; nuclear trafficking; and the nexus of organized crime and terrorist organizations.

Theft and Smuggling

The Soviet Union's chemical weapons program was in such disarray in the aftermath of the Cold War that some toxic and radioactive substances got into the hands of criminals or those who tried to sell these to them. While nerve agents degrade over time, if the precursor ingredients for nerve agents were smuggled out in the 1990s and stored under proper conditions and mixed more recently, these agents could still be deadly.

Attacking a nuclear power plant is difficult but not impossible. Terrorists could find a way to sabotage a plant, causing radiation to escape into the environment. In 1992, for example, a hacker named Oleg Savchuk was arrested for trying to sabotage the Ignalina Nuclear Power Plant in Lithuania using a computer virus.[50]

In August 2019, the Nuclear Threat Initiative (NTI) released an annual Global Incidents and Trafficking Database,[51] produced by the James Martin Center for Nonproliferation Studies (CNS). In 2019 alone, CNS recorded 167 incidents in 23 countries where nuclear and other radioactive materials were found outside of a regulatory control regime (this was an increase from 156 incidents in 2018). Among them: the loss of 1g of weapons-gram plutonium from a university laboratory in the US. Trends remain consistent with the data collected between 2013 and 2017. In 2018, 58 losses were recorded while there were 45 thefts. 64 incidents occurred during transport.[52]

Rogue State Trade

According to a 2017 UN report, two North Korean shipments to a Syrian government agency responsible for the country's chemical weapons program had been intercepted in a six months period. The goods were part of a Korea Mining Development Trading Corporation (KOMID)[53] contract with Syria's Scientific Studies and Research Centre (SSRC).[54]

Trafficking

While Slovakia is not a likely target for chemical weapons attacks, the substances needed for such an attack may have been smuggled through the country due to its geographic position and close proximity with areas where trafficking flourish. The Slovak Police Corps along with the Ukrainian police have been cooperating in detecting illegal CBRN materials at the Slovak-Ukrainian border for several years.[55]

In 2009, U.S. counterterrorism officials authenticated a video by an al Qaeda recruiter threatening to smuggle a biological weapon into the US via tunnels under the border with Mexico.[56] Smuggling a modern nuclear weapon across a border would be almost as easy as people smuggling and would present no trouble for professional people or drug smugglers. Approximately 350,000 people have been smuggled across the US-Mexico border in a typical recent year. The main issues are portability, which is really about size and weight (similar to that of a man) and weight and the probability of detection. Simulations of detection of mock-up nuclear bombs have been carried out in red teaming exercises.[57] In a widely reported stunt in 2002, ABC News smuggled a mock-up of a nuclear bomb (7 kg of depleted uranium shielded by a steel pipe with a lead lining) in a suitcase by rail from Austria to Turkey crossing several border checkpoints without inspection.[58]

In its *Dabiq* magazine issue No 9 (p.77),[59] one ISIS writer noted:

> "Let me throw a hypothetical operation onto the table. The Islamic State has billions of dollars in the bank, as they call on their wilayah in Pakistan to purchase a nuclear device through weapons dealers with links to corrupt officials in the region. The weapon is then transported overland until it makes it to Libya, where the mujahidin move it south to Nigeria. Drug shipments from Columbia bound to Europe pass through West Africa, so moving other types of contraband from East to West is just as possible. The nuke and accompanying mujahidin arrive on the shorelines of South America and are transported through the porous borders of Central America before arriving in Mexico and up to the border with the US. From there it's just a quick hop through a smuggling tunnel and hey presto, they're mingling with another 12 million "illegal" aliens in America with a nuclear bomb in the trunk of their car." [60]

Such statements highlight the potential risks in relation to the trafficking of weapons of mass destruction.

Recruitment of Scientists

Recruitments of scientists with a CBRN background can take several forms: it could take place following religious conversion; it could be an act of revenge against a previous employer; or it could be an embittered individual. Furthermore, it could follow after a direct threat against his/her life or against family members or relatives; the result of an impending job loss; the outcome of a business deal, or could also be a case of promising support to a scientist's

ambitions to make a new invention. For example, in 2014 when the Islamic State seized Mosul, geologist Suleiman al-Afiari was recruited and given the task to organize a supply chain for mustard gas, outfitting a small cluster of labs and workshops. He accepted because "I was afraid that I would lose my job. Government jobs are hard to get and it was important to hang on to it."[61]

Orphan Sources

'Orphan sources' are radioactive sources, which are not under regulatory control, or have never been regulated, or were left without attendance, were lost, placed at an inappropriate location, transferred without proper permission from the government or were stolen.[62] An "orphan source" falling into the hands of a regular citizen may lead to lethal consequences for those who touch these or get close to these radioactive objects. An example of such a situation was a radioactive contamination of 249 people with cesium-137 which occurred in 1987 in Brazil, costing the lives of four persons when the Institute of Radiotherapy in the town of Goiania moved to a new location, abandoning old radiation equipment.[63]

It should be mandatory to ensure that a radioactive source may only be used by individuals or enterprises who have proved to the state that they are capable of ensuring safety and security of the source. Governments should enforce accountancy and monitor and control all radioactive sources. Another preventive method is counteracting the potential threat of IRS (Industrial Radiation Sources) converted into the "orphan" category. The sources that may be abandoned are categorized as vulnerable.[64] Vulnerable sources are those radioactive sources, which are presently under control, but such control is insufficient for ensuring continuous safety and security.

Toxic Industrial Chemicals as Weapons

Toxic industrial chemicals can also be used as weapons. For example, an industrial catastrophe took place in India in 1984 when 3,800 people were killed while more than 11,000 others were injured when methyl isocyanate was released from the Union Carbide India Ltd (UCIL) pesticide plant in Bhopal.[65] While this was an accident, a deliberate attack on a chemical plant by terrorists might have an even larger effect.

The largest concern after the events of 11 September 2001 was for a while that chemical plants might be among the next targets. A terrorist could crash an aircraft or an armed drone against a chemical plant, resulting in the release of chemicals and expose the surrounding area to a plume of toxic gases. A bomb could damage storage tanks or transport vehicles carrying chemicals, releasing deadly toxins. Terrorists could get into an industrial plant and release toxic chemicals from within, or a disgruntled company employee could intentionally release toxic chemicals into the atmosphere. Most chemical plants around the globe are located close to urban areas; therefore, depending on the location, if toxic chemicals were released from one of those plants, as many as one million citizens could be killed, injured, or evacuated (US estimate). Approximately 850,000 U.S. businesses use, produce, or store toxic industrial chemicals (TICs).[66]

Military or civilian food or water supplies could also be threatened, directly or indirectly, by a terrorist attack with TICs. Contaminating animal feed is an indirect method of poisoning the food supply, spreading toxins to people who eat contaminated animal products. Depending on the chemical, the residual toxins indigested by animals could be enough to cause mass illness and possibly even death within a meat-eating human population.[67]

Dual Biotechnologies and Terrorists

Although the potential impact of a biological weapons attack can be significant, the likelihood is currently not believed to be high. Back in 1984, the Rajneeshee cult performed the first biological attack in the recent history of the US by poisoning with *Salmonella typhimurium* the salad bars of 10 restaurants in an effort to influence local elections in a town in Oregon.[68] In 1993, the Aum Shinrikyo cult was involved in bioterrorism exploitation with *Bacillus anthracis* to be used against the citizens of Tokyo first with a homemade sprayer from the roof of a cult building located in a residential neighborhood and later from a modified truck.[69] Days after the 9/11 massacre in 2001, five US citizens were killed and 17 got sick following exposure to *Bacillus anthracis* spores send by the regular mail service.[70]

Genetic engineering, toxicology, molecular biology, and related sciences could contribute to the development of new generations of biological weapons by increasing the virulence and antibiotic resistance of pathogens, enhancing non-transmissible agents for airborne transmission and creating organisms or biological agents capable to attack humans and entire ecosystems.

The Biological and Toxin Weapons Convention (BTWC)[71] entails prohibition of the development, production, stockpiling and acquisition of biological and toxin weapons. This convention is also apprehensive regarding the development of dual-use technologies in the areas of genetic engineering, biotechnology, and microbiology, for growth of products and processes that are capable of being used for purposes inconsistent with its objectives and provisions.

Rapid advances in gene editing and so-called "DIY biological laboratories" which could be used by extremists, threaten to derail efforts to prevent biological weapons from being used against civilian targets.[72]

One might wonder why one should spend money and scientific expertise to create novel bio-weapons for which currently no defenses are available, when at this moment a dynamite-loaded properly loaded truck (VBIED), with or without chemicals or a radioisotope, could do much harm and produce the effect intended by terrorists at a reasonable cost? One possible answer could be found in the sphere of scientific ambition when a scientist turns mad.[73] A gifted but frustrated scientist could cause havoc and spread a pandemic much more deadly than some of the known biological weapons of the past. A scientifically trained bioterrorist could get hold of the DNA of a virus and program it to disrupt or suppress certain cellular functions in human populations. He or she could also create chemical-resistant insects and then use these against the agricultural production of a country. Therefore, the scientific community, together with governments worldwide should create a framework regarding the extent and the depth of scientific research in critical areas because a rogue scientist might become terrorists too. This has apparently happened in the case of the anthrax attacks of 2001 in the United States. There Bruce E. Ivins, a microbiologist from a national biodefense laboratory, was found to be the chief suspect in the distribution of weapon-grade anthrax spores by mail. This is why better state supervision is mandatory - whether it is inside state, hospital, university or pharmaceutical industry laboratories.

Dirty Bombs and Terrorists

A "dirty bomb" or radiological dispersal device (RDD) is an explosive improvised device that combines conventional explosives, such as dynamite or C4, with radioactive materials. Most RDDs would not release enough radiation to kill more than a few people or cause severe illness. The conventional explosives would kill or injure more people in close proximity to the site of the explosion than the radioactive materials themselves. However, a RDD attack would create fear and panic, contaminate people and property, and require a costly cleanup. For "dispersal"

no explosives are needed. It could involve adding radioactive materials to a ventilation system (inhalation threat; expensive cleanup cost), spraying radioactive materials over a populated area with a crop duster or a drone, or contamination of water supplies (although the high dilution is not likely to result in individually significant injuries). In addition, radiological materials can be used in a radiation emitting device (RED, uncovered lead container) hidden in mass gathering places like a subway car or in the outpatient clinics department of a hospital. In addition, placing an IED in an area where radioisotopes are stored (nuclear medicine departments of hospitals) or used (cesium irradiators in hospitals' blood banks or radiotherapy units) may result in an outcome similar to the one of exposure to a dirty bomb. A capsule of Cobalt 60 (^{60}Co) used for cancer treatment typically contains about 7.4·1013 Bq (2000 curie), which corresponds to a mass of about 1.8 grams.[74] The same applies for sabotage of spent fuel transport cask and the corresponding release of radioactive aerosol.[75]

Until now no dirty bombs have successfully been detonated. However, the threat is not imaginary. A vivid example is the 2008 case of the millionaire James Cummings. In his home in in Belfast, Maine, USA, police found both radiological materials and technical literature on how to construct a dirty bomb.[76] Such a case indicates that the threat is real. Another example of potentially planned use was the discovery of explosives together with a radiological source (cesium-137) buried, by Chechen rebels, in the Izmailovsky Park in Moscow in 1995.[77] For a terrorist organization with even rudimentary IED capabilities, the design and building of the explosive elements of a dirty bomb would be relatively easy. Obtaining radioactive material in sufficient quantities to create a major radiological dispersal is, however, a much harder challenge and one which can be countered by appropriate monitoring of radioactive sources, their regulation and effective law-enforcement.

Improvised Nuclear Devices

An Improvised Nuclear Device (IND) is a primitive type of nuclear weapon. When an IND explodes, it gives off four types of energy: a blast wave, intense light, heat, and radiation. The idea of terrorists accomplishing such a big bang is, unfortunately, not out of the question; it is far easier to make a crude, unsafe, unreliable nuclear explosive that might fit in the back of a truck than it is to make a safe, reliable weapon of known yield that can be delivered by missile or combat aircraft.[78]

Could resourceful terrorists design and build a crude nuclear bomb if they had the needed nuclear material? Unfortunately, repeated examinations of this question by nuclear weapons experts in the US and elsewhere have concluded that the answer is yes – for either uranium or plutonium nuclear bomb, provided they can get hold of the required radioactive materials through theft or from trafficking.[79]

Nuclear Trafficking

The Black Sea region is a vital strategic crossroads between Europe, Asia, Transcaucasia, Russia, and the Middle East, and has long been used for smuggling of licit and illicit goods, including nuclear materials since the end of the Cold War. Over 630 nuclear trafficking incidents were recorded in Black Sea states between 1991 and 2012, almost half of them in or from Russia. Five of the recorded incidents involved highly enriched uranium (HEU), raising concerns about the region's use as a transit route for nuclear material smuggled from the former Soviet Union to the Middle East.[80]

The seizures of HEU samples in Georgia in 2010,[81] and Moldova in 2011,[82] suggest that some quantities of previously stolen weapon-grade nuclear materials may still be available for

illegal transfer and sale to state and non-state actors. Therefore, it is important that efforts to counter nuclear trafficking in the Black Sea region are continued and enhanced.

The terrorism-organized crime nexus could provide not only the basic nuclear material required for a radiological dispersal device or an improvised nuclear bomb but even an actual nuclear warhead to be delivered to the targeting site in the back of a truck or as payload of a drone.

IED – WMD Networks Nexus

Convergence between IED facilitation and WMD proliferation networks could also potentially lower existing thresholds, making the proliferation of WMD not only easier but more widespread. Networks are composed of people, material, infrastructure, money/finance, information, and lines of communications, which can be both physical and virtual. Perhaps the most notable WMD proliferation network was Abdul Qadeer Khan's nuclear technology network which stood at the basis of Pakistan becoming a nuclear power currently possessing more than 100 atomic bombs. While A.Q. Khan's network sold critical technology he stole from his time with URENCO in the Netherlands to state actors (e.g., Libya, North Korea) from his base in Pakistan, the father of Pakistan's atomic bomb could have sold know-how and nuclear materials to non-state actors as well.[83] This does not imply that a terrorist could easily develop and employ a nuclear weapon, but rather that there are profit-minded suppliers willing to sell crucial components to them.

In 2018, to respond to this new security environment and further restrict access to dangerous substances, the European Commission proposed to strengthen the existing rules – for both online and offline sales.[84] The proposed measures included:

1. Addition of new substances and concentration limits to the list of banned chemicals;
2. Inclusion on the list of economic operators of entities operating and selling online;
3. Background and criminal-record checks of public buyers;
4. Obligation to report a suspicious transaction within 24 hours; and
5. Greater awareness-raising and information sharing along the supply chain.

Conclusion

Attacks with CBRN materials and agents are not necessarily producing mass casualties or mass destruction. However, even a small-scale attack can become a game-changer and spread the fear pursued by all terrorists. It is a fact that a number of Islamist terrorist groups have expressed an intention to use CBRN materials and use these offensively rather than just as a deterrent. However, their capabilities are at the present time, in most cases, very low or non-existent.

Looking at various probable scenarios, a chemical attack is most likely, followed by a radiological attack. A serious biological offensive is currently beyond the means of most, and probably all, existing terrorist groups without state support; the same is even more true for detonating an improvised or stolen nuclear device. However, a suicidal attack on a nuclear power plant or a radiological waste storage site is a distinct possibility, while an attack on a chemical-industrial complex is even more probable.

In order to continue to be taken seriously, leading terrorist organizations like al Qaeda might aim to produce an incident bigger than 9/11, and if they cannot do so in terms of producing more casualties, they might seek a qualitative quantum jump with the help of CBRN materials and agents, especially a radioactive dispersal device (a "dirty bomb") which is likely to cause a short-term psychological shock and long-lasting local contamination.

At the present time, there is only a very low risk of catastrophic biological and nuclear terrorism but it is nevertheless real. On the other hand, chemical and radioactive attacks are much more probable, but pose a lower risk of mass casualties. Nevertheless, response agencies need to address all threats and identify as many as possible gaps that might attract terrorists' attention leading to an actual asymmetric attack. Appendix 1 list some preventive actions that ought to be taken to be prepared for both high risk and low probability events and high probability but low risk ones. This is followed by an Appendix listing some of the dual use problems on the horizon or already present when it comes to biological terrorism.

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Appendix

What can be done to Counter the Threat of CBRN Terrorism?

1. Intelligence collection priorities ought to focus strongly on proliferation issues associated with certain types of non-state actors such as jihadist movements, religious sects, racist groups and others who might be tempted to acquire weapons of mass destruction;
2. Trade in (precursor) materials for biological, chemical and nuclear substances must be subjected to better monitoring and greater control;
3. Existing conventions in the field of biological, chemical and nuclear weapons, terrorism and organized crime must be strengthened by adding (better) monitoring, implementation and sanction mechanisms;
4. International cooperation to counter proliferation and terrorism must be enhanced and bureaucratic "red tape and turf fighting" have to be minimized by creating more flexible and collaborative organizations;
5. Existing government stockpiles of nuclear weapons must be better guarded and accounted for, and ought to be gradually phased out or brought under international control. A credible multilateral nuclear disarmament program by governments will also put moral pressure on non-state actors to refrain from the acquisition of atomic weapons.

The major advantages of terrorists are the element of surprise and an innovative modus operandi since they are rapidly adjusting to countermeasures taken after each foiled attack. Surprise and innovation are two characteristics that cannot be easily matched. What can be done is the identification of gaps and vulnerabilities the same way terrorists are using these when planning their operations. Once we can leave behind us the deeply ingrained attitude that "it will not happen to us", both the effects of surprise and innovation can be limited to acceptable and manageable levels.

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Web-based Resources

CBRN Journals

- CBRNe World
- Chemical, Biological & Nuclear Warfare (CBNW)
- C^{2}-BRNE Diary
- C-IED Report
- NCT Magazine

CBRN Organizations

- Australia Group
- CBRN Special Interest Group of World Association for Disaster and Emergency Medicine (WADEM)
- International Atomic Energy Agency (IAEA)
- Nuclear Suppliers Group
- Organization for the Prohibition of Chemical Weapons (OPCW)
- Stockholm International Peace Research Institute (*SIPRI*)
- United Nations:
    - United Nations Office for Disarmament Affairs (UNDA) – Biological Weapons
    - United Nations Office for Disarmament Affairs (UNDA) – Chemical Weapons
    - United Nations Office for Disarmament Affairs (UNDA) – Nuclear Weapons
    - UN Resolution 1540
- Wassenaar Arrangement

CBRN Centers of Excellence

- CBRN Network of Excellence
- Community of Users on Secure, Safe and Resilient Societies
- European Biosafety Association (EBSA)
- The European Union Chemical Biological Radiological and Nuclear Risk Mitigation Centres of Excellence Initiative
- Global Initiative to Combat Nuclear Terrorism (GICNT)
- The International Forum to Advance First Responder Innovation
- The NATO Joint CBRN Defense Centre of Excellence

CBRN Training Centers

- Argon Electronics (UK)
- CBRN Defence Training Centre – Akademia Sztuki Wojennej (Poland)
- CBRN-E Training Centre, International Security and Emergency Management Institute, (Slovakia)
- Defence Chemical Biological Radiological and Nuclear Centre (DCBRNC) (UK)

- The European Nuclear Security Training Centre – EUSECTRA (Karlsruhe, DE and Ispra, IT)
- International CBRNE Institute (Belgium)
- Joint CBRN Defense Centre Of Excellence (Czech Republic)
- Seibersdorf Laboratories (IAEA, Austria)
- Serbian Armed Forces CBRN Centre (Serbia)

CBRN Registered Training Organizations

Belgium

- Centre de Technologies Moléculaires Appliquées (CTMA), Université Catholique de Louvain

Czech Republic

- National Institute for Nuclear, Chemical and Biological Protection

Germany

- The Bundeswehr Research Institute for Protective Technologies and CBRN Protection (WIS)
- Robert Koch Institute

Italy

- Observatory on Security and CBRNe Defense (OSDIFE)
- UNICRI – United Nations Interregional Crime and Justice Research Institute

Netherlands

- Netherlands Forensic Institute (NFI)
- TNO

Norway

- FFI

Poland

- Central Laboratory for Radiological Protection (CLOR)
- Faculty of Biology and Environmental Protection, University of Lodz
- Industrial Chemistry Research Institute (ICRI)
- Institute of Security Technologies MORATEX
- Military Institute of Hygiene and Epidemiology
- Military Institute of Chemistry and Radiology
- National Centre for Nuclear Research
- National Institute of Public Health – National Institute of Hygiene

Sweden

- European CBRNE Center, Umeå University
- FOI

UK

- Cranfield University

Ukraine

- International CBRN Risk Mitigation Research Center International

CBRNe Courses

- CBRNe Master Courses (Levels I and II) – Università di Roma "Tor Vergata", IT
- The CBRN Defense Science Course – Cranfield University, UK
- CBRN Defense Courses – NATO SCHOOL Oberammergau, DE

E-Learning

- EU Non-Proliferation and Disarmament eLearning Course
- FLIR Primed
- Disaster Information Management Research Center – CBRNE (Chemical, Biological, Radiological, Nuclear and Explosives): Health Information Resources Training Modules
- A guide to effective chemical warfare agent training
- Project 10 of the EU CBRN CoE initiative – The online training course

CBRNE Portals

- CBRNE Central
- CBRNe Portal
- CBRNPro.net
- CHEMM – Chemical Hazards Emergency Medical Management
- Federation of American Scientists
- Global Biodefense – CBRNE Articles
- REMM – Radiation Emergency Medical Management
- The Homeland Defense and Security Information Analysis Center (HDIAC)

Free CBRN Software

- ALOHA
- Biodetection Guide for First Responders (iTunes)
- CAMEO*fm*
- CAMEO Chemicals
- Clinicians Biosecurity Resource (iTunes)
- Mobile REMM – Radiation Emergency Medical Management
- WISER – Wireless Information System for Emergency Responder