Journal of High Threat & Austere Medicine

Guest editorial

Chemical, biological, radiological and nuclear threats: the herculean challenge of modern toxikons

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For referencing Schmidt R and Schmidt J. Chemical, biological, radiological and nuclear threats: the herculean challenge of modern toxikons. JHTAM. 2024;6(1):1-3.

DOI https://doi.org/10.33235/JHTAM.6.1.1-3

The use of toxic substances to achieve an asymmetric and psychological advantage over an adversary is not a new phenomenon. In Greek mythology, the hero Hercules slays the multi-headed Hydra and then dips his arrows in the serpent's venom, creating the first biological weapon, or *toxikon*. This super-weapon was critical to Hercules' achievement of his remaining Twelve Labours, but ironically also led to his ultimate downfall through a hydra poison-imbued tunic given as a gift. This myth, and many examples throughout history – traced back to the Hittites of Asia Minor, indicate extensive employment of naturally occurring or easily available toxikons in warfare to gain a decisive advantage.[1]

This editorial contends that the threat of modern toxikons – chemical, biological, radiological and nuclear (CBRN) materials – is increasing both globally and within the Indo-Pacific, as well as through the potential dual-use of emerging technologies for novel toxikon development. It also argues that Australia's preparedness and health response to the threat of these toxikons is lacking, while providing suggestions for priority focus.

The post-Industrial Revolution employment of chemicals such as phosgene and mustard gas during WWI demonstrated to the world a scale and efficiency of killing and maiming previously unseen, until the advent of the atomic bomb at the end of WWII. Since then, the threat of retaliation-in-kind has largely restrained major powers from employing CBRN weapons against each other, formalised through a range of international treaties and conventions towards the end of the 20th Century.

CBRN incidents have also resulted from releases other than attack. Nuclear accidents at Chernobyl in the former Soviet Union, Three Mile Island in the United States, and Fukushima in Japan underline the vast human and economic impact when things go wrong. Recent dangers involving the nuclear power station at Zaporizhzhia in Ukraine underline the risk of nuclear accidents or plausibly deniable deliberate radiation release during military conflict. These threats will remain ever-present, with approximately 140 nuclear reactors currently operating in Asia, with around 35–40 under construction and planning underway for an additional 55–60.[2] Australia will also need to be increasingly prepared for nuclear and radiological mishaps. Forecast increase of nuclear-powered ship and submarine visits from the United States and United Kingdom, as well as Australia's emerging nuclear industry following the decision to acquire conventionally-armed, nuclear-powered submarines, will require an uplift of incident response capability.

Moreover, with countries in the Indo-Pacific forecast to be some of the worst affected by climate change throughout the 21st Century, health security threats from zoonoses and other infectious diseases are forecast to increase as well.[3] The recent COVID-19 pandemic has demonstrated the massive global impact of a highly infectious but relatively low morbidity and mortality biological pathogen.

CBRN threats are also increasing globally. Erosion of the Rules-based Global Order has seen state-backed uses of chemical weapons in particular – Sarin nerve agent in Syria, VX nerve agent assassination in Malaysia, and attempted assassinations using the deadly Novichok nerve agent in the United Kingdom and Russia, to name but a few. Accelerating technology development and knowledge proliferation will continue to lower the barrier for state and non-state actors to develop their own toxikons for non-attributable impact, decisive strategic action, or to instil fear and demonstrate strength. Similar to Hercules's toxikon, there are risks and malign uses for some of the most promising technologies. In an experiment reported in 2022, a pharmaceutical company inverted the algorithm in their artificial intelligence (AI)-powered software for de novo drug discovery to instead design candidate molecules high in toxicity and bioactivity. After training the AI using a public database, it took less than six hours to identify 40,000 candidate molecules, including many plausible ones previously unknown.[4] Elsewhere, gene sequencing and editing technologies, such as CRISPR-Cas9, are now taught at high school level, increasing the opportunity for bioterrorism using genetically engineered pathogens by non-state actors or disenfranchised persons. Equally concerning is the

predicted advent of state-sponsored synthetic bioweapons able to target specific genotypes, including ethnicities.[5,6]

Despite the increasing threat, Australia's and much of the Western world's CBRN defence capabilities, including medical, appear to have atrophied significantly post-Cold War and since the 2000 Sydney Olympics security focus, despite a lack of research on this topic.[7] CBRN defence has been seen as a low-probability, high-consequence insurance policy, progressively deprioritised in constrained budgets during the rudimentary but high-impact Islamist terrorism focus of the early 21st Century. Given the current geopolitical instability and dual-purpose use of new technology, renewed focus and additional resources for CBRN medical preparedness and response are needed.

Regular exercising of Australia's CBRN defence capabilities, as well as strategic and operational coordination, is required to rehearse the complex response dynamics from a tapestry of lead ministers and agencies under the contingencies outlined by the Australian Government Crisis Management Framework. This has not been regularly practiced since 2010 in the last Mercury-series Multi-Jurisdictional Exercise, through the Australia-New Zealand Counter-Terrorism Committee. Policy must also keep pace, and the Department of Health and Aged Care needs to update the 2018 Domestic Health Response Plan for CBRN Incidents of National Significance, to meet their lead agency responsibilities for domestic public health and CBRN crises beyond just deliberate threats or release, and to institutionalise lessons learned from the COVID-19 pandemic response.

CBRN knowledge management should also be prioritised, with subject matter expert (SME) networks or communities of practice (CoP) established to harness knowledge for emerging threat detection, identification and response technologies, as well as to provide policy advice. The Safeguarding Australia through Biotechnology Response and Engagement (SABRE) Alliance and the Centre for Advanced Research and Enterprise – Operating in CBRN Environments (CADRE-OCE) consortiums of Defence, national security, academia, and industry are two examples of bases that these types of networks or communities of practice could be built upon.

At health practitioner level, the Australian Medical Assistance Team (AUSMAT) provides useful CBRN medical capability but suffers the same challenges as the Australian Defence Force (ADF) in that many of their specialist practitioners would be required in their primary frontline health roles during crises of national scale. Heslop and Westphalen[8] provide a persuasive argument for the expansion of occupational and environmental health skills in the ADF to manage CBRN hazards. These skills could also be broadened across civilian health and first responder workforces through a nationally-designed and assured, state and territory-implemented training framework, to build resilience and contamination control skills in the health system from point of injury or exposure through medical evacuation to hospital care.

Finally, a coordinated or centralised approach to stockpiling and, in some cases, domestic production of CBRN medical countermeasures (MedCM) is needed. By themselves, the National Medical Stockpile, Defence Stockpile, and isolated state and territory holdings are generally too small for prioritised orders in global pharmaceutical production lines, creating a lack of supply chain responsiveness and surety. Furthermore, Australia should employ what the US Joint Program Executive Office for CBRN Defense (JPEO-CBRND) terms *capability platforms* for the development or introduction of novel MedCM to provide risk mitigation against emerging threats. A MedCM capability platform is a proven technology plus a proven administrative approval process for emergency use that provides a platform able to be rapidly adapted toward similar threats. A contemporary example of this was the rapid development by JPEO-CBRND and emergency use authority of a novel monkeypox vaccine adapted from an existing smallpox vaccine, providing a level of risk mitigation in extremis without many of the costly clinical trials required for a traditional certified vaccine.

In summary, CBRN toxikons have remained an enduring threat throughout human history during conflict and peace, despite the relative restraint and international agreements post-Cold War. In actuality, the global and regional CBRN toxikon threat is increasing, through increased opportunity for accidental release, deliberate or deniable employment by state actors in defiance of the Rules-based Global Order, and through malign use of potential dual-use technologies by state and non-state actors. Despite the challenges presented by increased threat, Australia's collective CBRN preparedness and health response capabilities have decreased since the 2000 Sydney Olympics. This editorial has posited that Australia's Herculean Labours for remediation should focus on priority areas of (1) rejuvenated exercising of capabilities and coordination; (2) enhanced CBRN SME networks or communities of practice to innovate and adapt to emerging threats, and provide expert policy advice; (3) expanded occupational and environmental health skills for health practitioners; and (4) coordinated or centralised acquisition of MedCM to improve supply chains, as well as the adoption of a capability platform approach to rapidly develop new MedCM for in extremis use through risk-based decision making.

Disclaimer

The views expressed in this editorial are those of the authors and do not necessarily reflect those of the Department of Defence, Australian Defence Force, or any of the other organisations mentioned.

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