RAPID IDENTIFICATION TECHNOLOGY FOR PATHOGEN DETECTION

Problem

The ever-advancing threat of chemical, biological, radiological (CBR) agents against Australia's military forces and non-combatants is rapidly increasing. Central to this is the global proliferation of technologies capable of genetically altering biological agents to increase their potential virulence – an emerging defence priority referred to as synthetic biology. **Given the threat of emerging viral agents, the need for a near real-time, multi-agent threat identification systems is urgently required.** Current field forward presumptive based testing for biological agents includes antibody-antigen based agent identification assays (Handheld assays, HHAs), which present significant limitations. Antibody-antigen approaches can suffer from poor sensitivity and have shown to cross react with closely related bacterial species. Although highly sensitive, devices which detect nucleic acids via polymerase chain reaction (PCR) against Defence threat agents have longer cycling times (taking up to 1.5 hours for a result) and have power requirements which can pose substantial issues in locations where the ADF are often deployed. These current modalities cannot be rapidly modified to account for the emergence of novel agents, or those of regional significance to the Australian ADF. We urgently require a capability that is nimble and interoperable with coalition partners and Australian industry. Currently, a requirement exists for novel field-portable, rapid (<20 mins), and inexpensive nucleic acid presumptive testing to further enhance current approaches and facilitate early threat intervention.

Need and relevance to Defence

Given the unprecedented global transformation of CBR threats, the modern defence force needs to be equipped to adapt to multi-threat scenarios, to detect emerging bacterial and viral pathogens or novel threats of synthetic origin. The obvious need of a rapid, point-of-situation pathogen identification technology in the field is critical for the ADF and the first responder community to operate successfully in this evolving threat space. A technology which is flexible will enable the ADF to respond both rapidly and with confidence in the face of a CBRN event. This will achieve enhanced situational awareness and allow unimpeded movement in a complex and dangerous contaminated environment. Highly sensitive pathogen identification technology, operated by end-users, and without the need for specialised labs will lead to sustainable and inexpensive ways of improving Australia's preparedness, responsiveness and sovereign capability from emerging threats.

Research question

Can a multiplexed and ultrasensitive, low-burden, all-in-one nucleic acid detection assay be developed as a novel CBR agent identification system?

Expected outcomes

Here, we pose bridging the problem of being able to detect and monitor multiple traditional or emerging biological agents across extensive and challenging terrains swiftly and precisely. This novel system will be a pilot all-in-one agent identification without need for separate and complex manual operations. We aim to derive the proof-of-concept map to design a field-forward, low-burden viral nucleic acid identification system for multiple threats encountered by the ADF. Depending on the ADF threat environment, our proposal aims to deliver the first rapid and multiplexed nucleic acid identification technology – one that can reliably and with heightened sensitivity against current standards - pathogen identification within 20 minutes and with minimal power requirements. Our system should enable

readouts for up to 5 targets to be made for purpose depending on the mission context and is expected to be able to detect nucleic acids of pathogen agents with a sensitivity of only a few copies. This technology has the potential to allow us to further design assays and portable prototypes that are unique to Australia's military and first responders. This rapid feasibility study will provide a 12-month de-risking venture allowing us to engage potential industry partners early, with the intent to rapidly translate and commercialise our nucleic acid detection system. With support from the Safeguarding Australia through Biotechnology Response and Engagement alliance (SABRE) alliance. We envisage additional links to Joint Health Command, Special operations Command, and National Security in the CBR space – allowing us to strengthen stakeholder engagement within the ADF. Additionally, our newly generated knowledge in this domain will facilitate future SABRE-led funding applications to enable more leverage support for the development of the final low-burden device. The minimum viable product (MVP) we are seeking within DIN funded timeframe is the delivery of a rapid, specific, and low-burden multiplexed nucleic acid identification assay for approximately 5 targets. Further stages will develop this assay into an easy-to-use, field-forward pathogen HHA for CBR special operators.

Methodology/Approach

In collaboration with two DIN university partners, we aim to develop a nucleic acid detection system targeting common CBR threats as advised by stakeholders forming the steering committee of the SABRE alliance and special CBR operators. Specifically, this methodology will cover two distinct phases, including (1) assay development (2) optimization. Initially, we envisage implantation of data analysis tools to identify the unique genetic sequences of defined CBR threats. This will enable the templates to facilitate a nucleic acid targeting platform, possibly including microfluidics. Additionally, we aim to multiplex this system in a manner that will identify multiple targets and alert special CBR operators through inbuilt spectral and visual readouts. Within DSTG at the 12-month final stage, we will further test the systems feasibility by performing assays which will assess the sensitivity and specificity compared to current CBR assays. Additionally, to test our MVP, we will assess the assay across a standard curve (including low concentrations) of advised CBR threats, in-house, at DSTG. This will establish the principles and proof of concept for a low cost, low volume, all-in-one next-generation point-of-care molecular threat detection technology.