CRISIS RESPONSE
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Targeting refugees & victims of disaster

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A vital role in prevention

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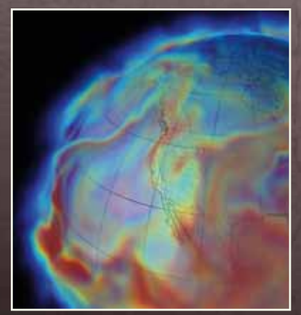

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comment

CRJ HAS FEATURED several articles about the Syria Civil Defence in the last two issues, but speaking to its volunteers face to face at their training ground, and listening to the descriptions of their lives and the horrendous conditions they confront on a daily basis, was beyond humbling (p22).

Not far from where we were talking, thousands of refugees were massing at the border, desperate to escape the twin threats of ISIS and the al-Assad regime.

Our cover story (p18) deals with the odious issue of human trafficking, a growing societal crisis, which is likely to get worse in the face of increased global conflict, terrorism, climate change-induced disasters and severe economic hardship. When men, women and children are forced from their homes, for whatever reason, they can become prey to cynical predators.

This year has been characterised by tragedies in the Mediterranean, with dozens of overloaded migrant boats sinking or needing rescue. Meanwhile, the town of Calais in France struggles to cope with a near-overwhelming influx of people taking unthinkable risks to try to reach the UK. Thousands of unaccompanied children fleeing violence in South American countries have been making their way into the US. These are just a few examples drawn from a global pool of misery.

So, what is the common narrative that links these issues?

Exploitation and crime invariably stalk vulnerable people and communities. There is no shortage of criminals waiting to take advantage of the desperate, the dispossessed, those who have fled with nothing, or who have lost everything, people already on the limits of human endurance.

Slavery, child soldiers, bonded labour, sexual exploitation, forced begging – some of these crimes are more overt than others – much of this activity goes unnoticed by most people in their daily lives. But aside from the unspeakable damage to the individuals involved, these crimes also have the potential to harm society, business and resilience in general.

Authorities, communities and individuals ignore this cycle of brutalisation, exploitation and forced criminality at their peril; we could be building up even greater problems – and threats – for the future.

Emily Hough

CBRN: Detection and identification innovations

The authors of this article describe four novel developments to improve the effectiveness and work performance of rapidly deployable CBRN analytical laboratories in crisis situations

Rapid detection and identification of agents at the scene of a major intentional, accidental or natural chemical, biological, radiological, nuclear (CBRN) incident is crucial to ensure adequate risk assessment, optimal risk management, and proper counter-measures, including medical treatment, personal protection and restored access to infrastructure. A determining factor in successfully responding to such an incident is the presence of a rapidly-deployable CBRN detection, identification and forensic capacity that can be located as close to the crisis area as possible, while maintaining vital information flows with crisis centre and incident managers.

There are many different ways to understand and develop mobile capacities as a counter-measure in a CBRN incident. Being able to determine the specific threat – ie whether chemical, biological, radiological/nuclear – is of paramount importance, as is having scalable capacities and joint multinational intervention according to available resources.

The Centre for Applied Molecular Technologies / Defence Laboratory Department – Biological Threats (CTMA/DLD-Bio) at the Université catholique de Louvain in Belgium is co-ordinating two international projects – MIRACLE and B-LiFE – funded by the European Commission (EC) and the European Space Agency (ESA), respectively. Both projects aim to provide laboratories with a set of new operational procedures and technology to improve rapid response, along with ICT tools for optimal CBRN crisis management.

The FP7-SEC MIRACLE consortium's objective is to harmonise the definition of a mobile CBRN laboratory, to define the needs of, and subsequently provide solutions for deployment of this capacity in and outside the EU. Meanwhile, the ESA B-LiFE consortium aims to equip the laboratory with new functions and capabilities derived from space research. These aims are complementary to the work carried out within the FP7-SEC PRACTICE project of which CTMA/DLD-Bio is a partner.

One of the CTMA/DLD-Bio's major objectives over the last five years has been to develop and validate rapid diagnostic tests for use in the field, while enhancing the ICT interface between the laboratory and the external world. To this end, it has developed the concept of a light, easily transportable testing capacity, which can be deployed rapidly, and that can quickly identify biological threats using nucleic acid-based techniques. This concept is called LiFi, standing for 'light fieldable'.

The goal is to have a rapidly deployable LiFi laboratory that can be used as close as possible to the contaminated area, and which can quickly, safely and specifically identify threats.

The laboratory aims to validate in-field tests, while reducing any problems related to biosafety by rapidly rendering pathogens inactive before molecular identification, providing cold chain for temperature sensitive reagents, and using space assets to access public and military databases. Simultaneously, it ensures two-way communication with other organisations involved in the incident, such as the crisis centre, local authorities, decision-makers, external experts, and so on.

The first new development concerns the handling and preparation of CBRN mixed samples. In any CBRN event, it is essential to provide fast and reliable analysis of samples containing a single C, B, R, N or other hazardous agent, such as toxic industrial materials. The true challenge, however, lies in processing mixed CBRN samples, as this requires adequate reception units, personnel safety procedures and specific containment facilities.

A simple, rapid and efficient ultrafiltration procedure for separating and safely handling samples that contain a mix of chemical and biological agents (CB mixed sample) in liquid and solid matrices has been developed and thoroughly validated. Parameters were set up to assess the performance of this simple method, first optimised on separate C- and B-agents, and then assessed on a model of a CB mixed sample, including biological agents (viral nanoparticles, bacteria or spores) and chemical compounds (surrogates for the nerve agent Soman).

The efficacy of ultrafiltration for separating a CB mixed sample into its C and B counterparts has been demonstrated by using quantitative performance indicators for both types of compounds. While allowing a separate analysis of each compound in optimal safety conditions, this method also improves the processing of unknown CBRN samples – an important contribution towards enhancing preparedness and consequence management in the fight against terrorism.

Before implementing this method in routine CBRN separation procedures, it is still essential to consider carefully the type of genomic material and matrix to be addressed, and to optimise the recovery parameters and conditions of the model. A representative spectrum of biological agents, particularly nano-sized biological particles extended to other viruses, should therefore be included in the assessment of the separation.

The light field-deployable laboratory with ICT capacity was designed to improve rapid detection and identification of agents at the scene of a CBRN incident

The complexity of these parameters prompted a BFREE project to be set up under the aegis of the European Defence Agency and its Joint Investment Programme on CBRN protection. This international consortium, co-ordinated by Norway, includes Belgium, Germany and Sweden, and is supported by French, Dutch and Austrian CBRN military laboratories.

Enzymatic replication

Development of new rapid and specific isothermal biothreat detection tests is another area being expanded upon. After unknown samples have been processed in such a way that they only contain separated CBRN agents, the detection and reliable identification of biological warfare agents (BWA) must be performed rapidly, using specific and highly sensitive tests.

Traditionally, this has been carried out using Polymerase Chain Reaction (PCR) or quantitative PCR (qPCR). This method relies on thermal cycling, consisting of cycles of repeated heating and cooling of the reaction to allow nucleic acids to melt (ie double strand DNA splits into two separate strands) and enzymatic replication of each target within the strands (ie amplification of these targets into billions of copies) while also reflecting the original amount of the target (a process called quantification).

However, newly-emerging technologies that allow ultra-rapid amplification of nucleic acids are more suitable than traditional methods for in-field use in a crisis situation, as turnaround time is vital for rapid and accurate command and control decisions

The CTMA/DLD-Bio has been developing such emerging technologies. For example, the so-called 'isothermal' method enables the amplification of targeted nucleic acids at a constant optimal temperature ranging between 37° and 65°C. This is carried out using a compact portable Twista fluorimeter instrument. Weighing one kilo, this basic equipment can replace the larger, heavier and more expensive conventional thermal cyclers currently used. These weight and cost advantages mean that isothermal amplification methods are attracting increased interest for the rapid detection of BWAs and, in particular, for diagnosing infectious diseases and their causative agents in general.

There are several isothermal amplification methods, including Loop-mediated isothermal amplification (LAMP), Transcription-Mediated Amplification (TMA) and Recombinase Polymerase Amplification (RPA). From an analytical point of view, one of the most interesting features of those methods is their low sensitivity to PCR inhibitors that can frequently be present in clinical and environmental samples.

RPA is a suitable method because it uses very stable reagents which can easily be transported to remote areas without cold-chain constraints. RPA is an ultra-fast method, which can swiftly be carried out and readily interpreted by first ▶

responders without specific analytical skills.

For this reason, CTMA/DLD-Bio is developing a series of RPA tests targeting *Bacillus anthracis*. Preliminary In-field validation has met optimal detection conditions as defined by our group in a recent review (ie, rapidity, sensitivity, accuracy, robustness, simplicity, low cost and very low hazard-risk). Isothermal detection methods, and RPA in particular, appear therefore to have the potential for substantially improving the effectiveness and work performance of in-field analytical laboratories.

The third issue to be examined is the need for simultaneous testing of unknown samples. RPA and traditional methods, such as qPCR, are specifically designed to detect or identify a single biological agent at a time. To use these efficiently, the optimal choice of RPA and qPCR targets has to be supported by pre-awareness, ie clinical and/or epidemiological evidence, such as medical intelligence, an existing outbreak, typical clinical or biological symptoms, etc.

Assay development

However, there is typically no pre-awareness in CBRN scenarios, with laboratories having to carry out successive identification tests, excluding the most harmful BWAs one by one; it causes extra work for staff, wastes precious time and costly reagents, consumes valuable sample material, and presents a risk of false positive results owing to sample contamination. Ultimately, all this can lead to detrimental delays in decision-making.

CTMA/DLD-Bio is currently developing a novel multiplex microarray assay to detect the main BWA pathogens in a single test. Such simultaneous testing methods usually require heavier equipment and are more time consuming, but they do enable the detection and identification of all major human pathogens in a single run. If further miniaturisation and development of equipment can be achieved, multiplex testing is undoubtedly one of the most promising methods to be integrated into a LiFi laboratory.

The fourth area of development involves ontology as a new way of increasing the operational performance of deployable capacities. A laboratory's structure, operational performance and integration with other deployed capacities are also of tremendous importance for efficient crisis management.

> If further miniaturisation and development of equipment can be achieved, multiplex testing is one of the most promising methods for the LiFi

As a better knowledge on CBRN deployable capacities and their technological challenges has now been acquired during the MIRACLE project, an ideal and harmonised CBRN mobile laboratory structure can be developed. This structure considers similarities and differences between existing capacities across the world, while unifying and generalising practical experience in building capacity in light, field deployable assets.

The concept of a light field deployable capacity structure comprises various interlinked components (staff, laboratory equipment, communication tools). All technologies and processes constituting the laboratory components are seen as tools that are used by staff to execute operational functions (such as activities to identify and counter CBRN threats, or to respond to and recover from CBRN incidents/attacks). The heterogeneous nature of tools, as well as variety of data formats and types of output, require a single management system that allows increased information sharing across each component. Moreover, it requires aligning terminology, functions and tools while complying with standards, best practices and operational procedures of use within the operational domain.

Perhaps the biggest challenge when considering the need to handle a large diversity of tools within a single capacity is that of making it effective and user-friendly.

Harmonising a concept that combines so many different elements from available light field deployable capacities addressing such a wide diversity of CBRN disciplines across so many EU countries requires an ontological approach. Information sharing and reuse must be enabled.

So, the mobile laboratory is seen as an operational capacity and the ontological approach establishes relationships and constraints on interrelationships. This provides consistent and unambiguous modelling of laboratory procedures, operational functions and tools, while identifying those that are incompatible with a given task or mission.

In summary, the integrated harmonised vision of a CBRN light field deployable capacity aims to strengthen users' operational capabilities in disaster response. It improves the exchange of critical information, bridges gaps between various tools and users, and increases flexibility by providing situational awareness and supporting better decision-making by all actors involved. It merges the innovative integrated technology solutions in the field of CBRN agent identification with communication technologies that have been validated during deployment in genuine operational conditions. CRJ

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