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Federaal Kenniscentrum voor de Gezondheidszorg
Centre Fédéral d'Expertise des Soins de Santé
Belgian Health Care Knowledge Centre

ORGANISATION OF MEDICAL CARE IN CBRNE INCIDENTS – A GUIDANCE

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JUSTIEN CORNELIS, MARIE DAUVRIN, ANJA DESOMER, SOPHIE GERKENS, CÉLIA PRIMUS-DE JONG, WENDY CHRISTIAENS

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COLOPHON

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FOREWORD

A number of unprecedented crises, such as the terrorist attacks of 2016 and the recent covid pandemic, are still fresh in everyone's minds. These events put a high strain on both our healthcare system and emergency response mechanisms, raising awareness of how crucial it is for our country to be well prepared for future crises. In this light, the FPS Public Health asked KCE to look into the organisation of hospital care in the event of so-called CBRNe incidents: emergencies involving the release of chemical (C), biological (B) or radiological/nuclear (RN) substances, whether or not by means of explosives (e).

This report mainly focuses on emergencies involving a release of chemical substances with immediate or slightly delayed effects (manifesting within a few hours). How should hospitals prepare? Which hospitals should take on what tasks? Such considerations also automatically raise the question on how first aid – and particularly medical care – should be organised at the disaster scene, as this has a subsequent impact on hospital care. How can all involved emergency workers from various disciplines (the fire brigade, civil protection, the army and healthcare professionals) collaborate to provide immediate assistance to the victims in the field? What agreements already exist in Belgium, and is there still room for improvement?

This report does not aim to cover every operational aspect, but hopes to provide guidance for the healthcare organisation both at the disaster scene and in hospitals when CBRNe incidents occur. Such incidents can take many different forms, and the nature of the threat is continuously changing and evolving. Therefore, the healthcare system must be able to adapt in a dynamic and flexible way to provide an appropriate response in all circumstances. No one can foresee the future, and we will never be completely ready for every possible emergency that may arise. We can, however, provide key elements that will make it possible for our country to deal with such situations, which everyone hopes will never occur, in the best possible way.

Christophe JANSSENS
Deputy general director

Marijke EYSSEN
General director a.i.

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LIST OF ABBREVIATIONS

Abbreviation	Full appellation in English	Full appellation in Dutch (abbreviation)	Full appellation in French (abbreviation)
BABI	Belgian Association for Burn Injuries	Belgian Association for Burn Injuries (BABI)	Belgian Association for Burn Injuries (BABI)
CST	Crisis Support Team	Crisis Support Team (CST)	Crisis Support Team (CST)
DIR-MED	Medical Director	Directeur Medische Hulpverlening (DIR-MED)	Directeur de l'Aide Médicale (DIR-MED)
Dispatching112	Emergency dispatching 112	Noodcentrale 112 (NC112)	Centrale d'Urgences 112 (CU112)
ED	Emergency Department	Spoedgevallendienst	Service d'urgence hospitalier
FHI	Federal Health Inspector	Federale Gezondheidsinspecteur (FGI)	Inspecteur d'hygiène fédérale (IHF)
FPS Internal Affairs	Federal Public Service Internal Affairs	Federale Overheidsdienst Binnenlandse Zaken (IBZ)	Service public fédéral Intérieur (IBZ)
FPS Public Health	Federal Public Service	Federale Overheidsdienst Volksgezondheid	Service public fédéral Santé Publique
HART	UK Hazardous Area Response Teams		
HEP	Hospital Emergency Plan	Ziekenhuis Noodplan (ZNP)	Plan d'Urgence Hospitalier (PUH)
MHQA	Military Hospital Queen Astrid	Militaire Hospitaal Konining Astrid (MHKA)	Hôpital Militaire Reine Astrid (HRMA)
MIP	Medical Intervention Plan	Medisch interventieplan (MIP)	Plan d'Intervention Médical (PIM)
MUG-SMUR	Emergency Mobile Service	Mobiele Urgentie Groep (MUG)	Service Mobile d'Urgence (SMUR)
NCCN	National Crisis Centre	Nationaal Crisis Centrum (NCCN)	Centre de Crise National (NCCN)
ORSEC	French Organisation of Civil Security Response		Organisation de la Réponse de la Sécurité Civile (France)
PIT	Paramedical Intervention Team	Paramedisch Interventie Team (PIT)	Paramedical Intervention Team (PIT)
PPE	Personal Protective Equipment	Persoonlijke beschermingsmiddelen (PBM)	Equipement de protection individuelle (EPI)
PSM 1	French Mobile Health Unit type 1		Poste Sanitaire Mobile type 1 (France)
PSM 2	French Mobile Health Unit type 2		Poste Sanitaire Mobile type 2 (France)
RAP	Rapid Assesment Procedure		

RD	Royal Decree	Koninklijk Besluit (KB)	Arrêté Royal (AR)
SIT-FIT	First Intervention Teams	Snelle Interventie Teams (SIT)	First Intervention Teams (FIT)
SOP	Standard Operating Procedure	Standaard Operationele Procedure (SOP)	Procédure Opérationnelle Standardisée (POS)
WHO	World Health Organisation		

1 INTRODUCTION

Triggered by historical events such as the sarin attack in Tokyo, 9/11, the nuclear incident in Fukushima, the terrorist attack in Brussels in 2016, the Ebola epidemic, and COVID-19 pandemic governments around the world feel the need to be adequately prepared to respond to chemical (C), biological (B), radiological (R), nuclear (N) and explosive (e) emergencies, called CBRNe-events. In the past decade the (risk of) exposure to dangerous products has increased due to technological advances and the threat of terrorism with the use of unconventional weapons.[1, 2] The threats can be either unintentional accidents or intentional terrorist attacks.

1.1 All-hazards approach to CBRNe emergencies

The umbrella concept of CBRNe has evolved over time into an all-hazards approach. In Belgium, CBRNe events are defined by an Interministrial Decree as:

> "*Emergency situations involving the release of Chemical, Biological or Radiological/Nuclear substances (whether or not involving the use of explosives) either as a result of (i) accidental, unintentional events (e.g. industrial accidents, pandemics), or as a result of (ii) malicious actions (e.g. terrorism), or (iii) through the use or presence of military equipment, installations or agents which require multi-disciplinary management and/or coordination at national level*".[3]

The multidisciplinary management refers to the collaborative work of the fire brigade (D1), the medical discipline – including the Red Cross (D2)[a], the police (D3), civil security services – including the armed forces (D4), communication providers (D5), etc. Note that the armed forces can be also involved in security (D3) and the medical discipline (D2) for example with the CBRNe MUG-SMUR. The definition used in Belgium is somewhat narrower but still similar to the all-hazards approach formulated by the North Atlantic Trade Organisation (NATO)[4]:

> "*The traditional Nuclear, Biological and Chemical (NBC) threats of a state attack (Article 5 NBC Defensive Operation) has evolved into a **CBRNE³T** all-hazard spectrum. For medical personnel, an all-hazards approach includes **C**hemical, **B**iological, **R**adiological, **N**uclear & **E**xplosives threats and **E**nvironmental and **E**ndemic hazards, and **T**rauma (**CBRNE³T**). This concept reflects the additional hazards presented by radiological material, explosives, environmental (including industrial) hazards, and endemic disease. All of these hazards could generate CBRN casualties, or mimic CBRN, that may require a CBRN medical response. For some hazards, a CBRN response may be an appropriate initial response due to safety and forensic considerations and encompasses the broadest understanding of CBRNe*."

This definition adds environmental hazards and endemic hazards to it, making it an 'E³'. Also the 'T' is added to the acronym to highlight that most of these incidents can evoke serious trauma lesions. Thus, the conceptualization of CBRNe is characterized by three (evolving) components; the acronym used, the agents (often described by the acronym) and the nature of the event (i.e. intentional terrorist attacks and targeted violence versus unintentional accidents).

The application of an all-hazards definition widens the scope of CBRNe incidents to encompass a range of emergencies involving at least one of the four agents (i.e. C, B, R, N), intentional (terrorist) attacks causing mass

[a] The Belgian Red Cross is listed in the medical intervention plan (MIP) as D2. They have also a major role as part of the D4 as they are in charge of providing rapid respond resources: according to some interviewees, the role of the Red Cross volunteers without a training as health care professional (112-ambulancier, nurse or doctor) is limited to providing logistic support as part of the D4 and they therefore are not being considered as part of the D2.

casualties, and incidents with high impact on society and/or environment (e.g. disasters such as hurricane Catherina, nuclear meltdown or pandemics).

1.2 Preparedness to respond to CBRNe emergencies

CBRNe incidents/attacks may have serious consequences for the health of a large number of people. Therefore, governments and healthcare systems need to be prepared to respond adequately. However, several studies demonstrated a lack of preparedness in Belgium:

- A study of the European Parliament[5] found that the preparedness of most members states is suboptimal and needs to be improved. Regarding Belgium, the report states '*Belgium ranks 5th highest in the overall threat score but is the lowest in preparedness. This indicates a potentially significant deficiency to respond to threats.*'
- A systematic review[6], based on 60 studies originating from 12 countries, found that there was evidence that hospital emergency departments (ED) lacked preparedness regarding decontamination capacity, security, and the availability of protective equipment and antidotes.
- A 2007 survey[7] among 100 Belgian hospitals concluded that "*There are serious gaps in hospital preparedness for CBRN incidents in Belgium. Lack of financial resources is a major obstacle in achieving sufficient preparedness*". The study[7] showed that preparedness of hospitals for CBRNe incidents in Belgium was rather low. The authors pointed out that among the 100 responding hospitals, for example only 11 hospitals had decontamination facilities outside the ED entrance, and only 6 hospitals had appropriate PPE available. Isolation facilities and specific antidotes were rarely foreseen and countermeasures were not broadly distributed throughout the hospital networks. In addition, the International CBRNe Institute in 2017 stated that the medical sector is the weakest link in all national CBRNe emergency response plans in Belgium.[8]
- Another survey among Belgium hospitals was carried out in 2013 and found that hospitals are in need of supporting tools (e.g. website, knowledge platform to share experiences and information, a uniform hospital emergency plan, manual, exercises, etc..) to improve their CBRNE preparedness.[9]
- An evaluation of the Belgian preparedness for Ebola in 2015[10] concluded that *"a broader legal framework to support and back up hospitals might be needed. Such a framework would ensure the continued support of hospitals once they have committed to become a 'designated hospital' for the treatment of resource-intensive cases.*"

The evaluation of the 2016 terrorist attacks at the airport and metro in Brussels however was rather positive and learned that the emergency plans generally worked well [11, 12]. This was also the case for the COVID-19 pandemic.[13] This can be due to some initiatives recently developped (see Box 1).

Box 1 – Belgian and European initiatives

In recent years, much has evolved on the European and Belgian level.

- The European Union made up an action plan[14] and created a European Network of CBRN Training Centres (see more: https://www.h2020-enotice.eu/).
- In Belgium several agencies worked on general disaster and specific CBRNe plans which led among others to:
  - A Joint Ministry Conference installing in 2016 a national hospital emergency plan,
  - The Royal Decree of 19 June 2018 establishing the national emergency plan on dealing with a criminal incident or terrorist attack involving chemical, biological, radiological and nuclear agents,
  - The establishment of a CBRNe expertise centre within the National Crisis Center (*Nationaal Crisis Centrum NCCN Centre de Crise National*) of the Federal Public Service Internal affairs,
  - The Royal Decree of 1st March 2018 establishing the nuclear and radiological emergency plan for the Belgian territory.

However, there remain questions on whether or not the Belgian hospital organisation is adequately prepared for all types of CBRNe threats and mass casualties.[13] CBRNe incidents have the potential to kill and maim on a large scale. Hence, this type of incidents can quickly exceed the ability of the affected community to cope using its own resources and put a high strain on the healthcare system. It is important to understand and optimize disaster health management.[15]

1.3 Aim and research questions

We aim at providing future directions to the organization of hospital and prehospital emergency response to a CBRNe incident in Belgium. Therefore we addressed the following research questions:

1. How are the hospitals currently organized in Belgium to cope with and be prepared for a CBRNe incident? (**RQ1**)
2. What do stakeholders consider as strengths, weaknesses, opportunities and challenges towards the organization and financing of hospitals to cope with and be prepared for a CBRNe incident? (**RQ2**)
3. How are hospitals in other countries organized to be prepared for a CBRNe incident? Which lessons can be learned from other countries to potentially optimize the organization of Belgian hospitals to be prepared for a CBRNe incident? (**RQ3**)
4. Which elements are suggested by literature to increase Belgian hospitals' preparedness to respond adequately to CBRNe incidents? Which lessons can be learned from the literature to potentially optimize the organization of Belgian hospitals to be prepared for a CBRNe incident? (**RQ4**)
5. What are potential future directions to optimize the organization of hospitals in Belgium in the case of a CBRNe incident? (**RQ5**)

1.4 Scope of the report

Regarding prehospital and hospital organization, **the emphasis in this report is primarily on C**, and more specifically C with acute (after seconds to minutes) or slightly delayed (after minutes to hours) effects. The prehospital and hospital organization proposed in this report apply less to C incidents with delayed long-term toxicity, B incidents which are often stretched over time, and RN incidents that result in symptoms due to ionizing radiation exposure or contamination by radioactive materials that are not identified at an early stage, although they bring about a greater risk of secondary contamination and are therefore an even greater challenge to the healthcare system.[16] Regarding the preconditions at healthcare system level, as specified in this report we adopted an all hazards approach.

Also this report provides **conceptual future directions** regarding the organization of hospital and prehospital response to CBRNe emergencies. It does not address operational issues (e.g. which antidotes should be available in hospitals or how many type I CBRNe hospitals (see chapter 4 and 4.3) do we need).

Finally, the focus of this report is on **organizational aspects** of the hospital and prehospital response in connection with the overall healthcare system, **not on the financial preconditions or consequences**. Financial consequences will depend on the organizational choices that will be made. Within the available timeframe, it was not feasible to make simulations for each of the proposed future directions. This would require a separate study. The countries studied were little informative regarding financing modalities as they depend highly on the general organization of the country's healthcare system and the extent to which other actors such as the armed forces are involved. Translation to the Belgian context is therefore unfeasible. Because of the confidentiality of financial information and the sensitivity of the topic in terms of national security, budgetary information was difficult to retrieve.

It is important to understand that health systems in all countries are under considerable pressure on a daily basis. Therefore it is undesirable to layer additional pressure or alternate responsibilities or accountabilities to that system, already under strain. For that, we focussed on 'mainstreaming' these accountabilities, and not simply adding on more. Health systems need to have flexible and scalable response arrangements which meet not only the daily challenges but also the exceptional challenges posed by disasters and major incidents. Therefore, we focus in this report on strengthening structures that work well, and to optimize and align processes and operations already in place.

2 METHODS

2.1 Introduction

The aim of this report is to provide future directions to improve the resilience of the Belgian healthcare system in general and hospitals in particular in the event of a CBRNe incident. In short, we rely mainly on:

- International scientific literature on healthcare system and hospital resilience, emergency preparedness and management relative to CBRNe incidents,
- Documents and reports describing CBRNe preparedness in Belgium and a selection of countries (i.e. France, the United Kingdom, the Netherlands, Norway and the United States of America),
- Challenges and overview regarding the current state of preparedness in Belgium identified through key person interviews,
- Experts consultation by means of workshops on how to counter these challenges and build an organisational model for an adequate hospital and prehospital response.

2.2 International scientific literature on hospital resilience frameworks

A pragmatic search was conducted in PubMed with keywords related to hospitals, preparedness, and emergencies, to retrieve review articles describing indicators related to the conceptualization and evaluation (such as frameworks) of hospital resilience. With this search it was aimed to understand which elements contribute to hospital resilience in case of CBRNe events and to integrate them in hospital emergency plans (see section 4.4.1). Only articles written in English and published over the last 5 years were included. After screening on title, abstract and full-text, 14 studies[17-30] were included describing specific elements for implementation in order to enhance preparedness and consequently resilience of hospitals towards CBRNe emergencies. The search for key documents to provide a general description of 'what is CBRNe', 'health system resilience' and

'hospital resilience' and an illustration of (conceptual) framework, were conducted through desktop research and snowballing.

2.3 Elements from other countries

2.3.1 Selection of countries

We adopted the following strategy to select countries:

- Countries with recent and well-developed CBRNe plans according to the Health System and Policy Monitor (HSPM) network of the European Observatory on Health Systems and Policies;
- Countries with high threat score and better preparedness than Belgium based on the report of Booz Allen Hamilton (2017)[5];
- Countries that are selected for their 'best practices' according the Belgian stakeholders interviewed in chapter 4;
- Neighbouring countries of Belgium, sharing common CBRNe risks (e.g. nuclear plants or SEVESO enterprises close to the frontier) and, eventually, cross-border cooperation agreements.
- Availability of the documents in Dutch, English, French, German or Spanish.

Based on these 5 criteria, 5 countries were selected: France, Norway, The Netherlands, United Kingdom (UK) and United States of America (USA). This selection was validated by the Belgian stakeholders.

2.3.2 Data collection

We collected data via a pragmatic literature review (specifically on hospital resilience frameworks), including official documents published by the public health authorities and / or authorities in charge of civil security and homeland defence in the selected countries, grey literature such as procedures and guidelines, and scientific literature when available. Information was searched via the official websites of the public authorities and via Google (Scholar) and PubMed by using the following keywords: 'CBRNe plan', 'management', 'organisation', 'hospital', 'training', 'hazard', 'pre-hospital medical chain' and 'hospital emergency plan' + the name of the country concerned. Literature search was completed by email exchanges with national experts identified in the literature or on the websites of the public authorities. We held semi-structured interviews via Zoom to gather additional information.

2.4 Interviews with key Belgian actors

To identify and understand difficulties in the management of CBRNe incidents, we conducted 40 face-to-face or online interviews with front-line staff, clinical experts and government administrators between May 2022 and the end of September 2022.

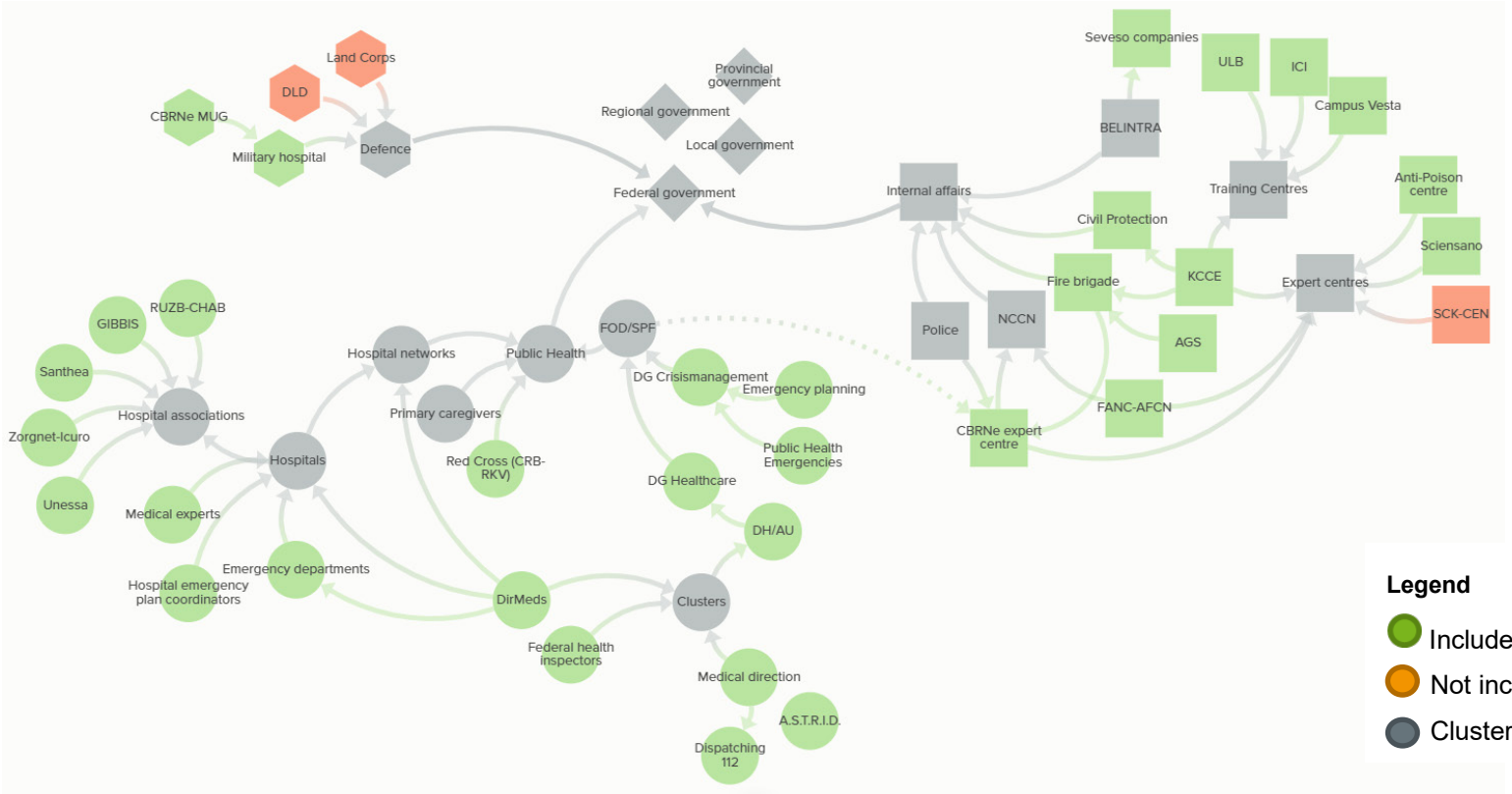
2.4.1 Face-to-face and online interviews

The key person interviews were exploratory and were designed as a rapid appraisal. In rapid qualitative research data are collected and analyzed in an iterative way within limited timeframes, often to 'diagnose' a situation.[31] The semi-structured interviews were carried out online by means of commonly available video-conferencing software. They were audio recorded with consent of the participants. Audios have not been transcribed. Instead rapid assessment procedure (RAP) sheets were used to synthesize findings on an ongoing basis. RAP sheets are commonly used in rapid qualitative research to summarize findings while data collection is ongoing. RAP sheets consist of a table categorizing information according to topics predefined by the interview guide as well as unanticipated topics emerging from the data.[32]

2.4.2 Sampling

The interviews were carried out with a purposive sample of front-line staff, clinical experts and government administrators as mapped in Figure 1. In addition snowballing was used, as we asked interviewees who else could be of interest for interviewing.

Figure 1 – Stakeholders involved in CBRNe



2.5 Expert consultation by means of workshops

In order to develop an organizational model for hospital and prehospital emergency response, Belgian experts in the field of CBRNe have been consulted by means of three workshops.

2.5.1 Selection of participants

A balanced mix of participants in each language group represented both operational and strategical expertise regarding CBRNe and/or emergency management in hospital and prehospital context. The groups included people who were able to think from a macro perspective, transcending the interests of individual hospitals. They were head of a hospital ED with or without the function of medical director (*directeur medische hulpverlening – directeur de l'aide medical* DIR-MED), hospital emergency plan (HEP) coordinator, federal health inspectors FHI (*Federale Gezondheidsinspecteur- Inspecteur d'hygiène fédéral*), medical advisor CBRNe and disaster management of the Belgian armed forces, or medical director of the Dispatching 112 (*noodcentrale 112 – centrale d'urgence 112*).

All invited participants had been interviewed as key person during the exploratory phase of the project except for the head of a hospital ED without a function "mobile emergency service" MUG-SMUR (*Mobiele Urgentie Groep (MUG) – Service Mobile d'Urgence (SMUR*)). In preparation of the meetings, the latter has been met by one of the researchers to introduce the project.

Twenty five experts have been invited to participate, among which five Dutch speaking and nine French speaking experts accepted to participate. Among the French invitees three experts proposed a substitute because they were unavailable on the days the workshops were planned to take place. Among the Dutch invitees one expert was unable to participate and could not be substituted. Nevertheless two online individual meetings (replacing the Dutch unilingual and the bilingual plenary meeting) were organized before the plenary meeting took place, to include his expertise anyway.

2.5.2 Aim of the workshops with CBRNe experts

The aim of the workshops was formulated by means of a conceptual tool which is used to guide a modelling process in soft systems thinking, and which is called CATWOE. CATWOE suggests six elements (Customers, Actors, Transformation process, Worldview, Ownership and Environmental constraints) to focus on when constructing the root definition of a human activity system. These models express what activities are being performed by people in pursuit of a given purpose and how these activities are logically interdependent. The activity models do not describe the problematic situation as such but are relevant to it in such a way that they trigger a series of interesting questions. Their value is heuristic rather than descriptive.[33]

A root definition is a concise, tightly constructed description of the human activity system in which the problem is situated. It takes the following generic form: "A system owned by O and operated by A, to do X by Y to beneficiaries C in order to achieve Z within constraints E." [34]

The aim of the workshops was formulated as a root definition which was the following:

The co-creation of an organizational structure incorporating healthcare providers (e.g. emergency responders) and institutions (e.g. hospitals)| that defines the role or each actor| in order to adequately manage and respond to CBRNe incidents| as part of a multidisciplinary chain of actions| operated by skilled healthcare professionals and technical experts trained according to the highest applicable standards of professionalism and scientific evidence| provided with the necessary financial resources and consolidated in a legislative framework.

This root definition together with the scope of the workshops has been communicated to the participants about one week beforehand.

2.5.2.1 *Scope of the workshops*

In addition to the aim we also specified the type of CBRNe incidents the experts had to focus on to define the organizational structure.

This organizational structure, as specified in the aim, should enable the management of a CBRNe incident that strains the operational chain of the Belgian healthcare system – prehospital and hospital – for a relatively short period of time (i.e. a number of days, weeks or months, but not years) due to:

- An unintended explosion I or other event involving C or RN
- A planned attack (e) with C or RN

The CBRNe incident hypothetically results in 150 to 350 casualties (both T1, T2 and T3), i.e. more than the maximal medical intervention plan (maxi-MIP) is currently aligned with.[35]This must take into account people who are contaminated and evacuate on their own initiative ('self-evacuations') and present themselves (unannounced) in an ED. With a CBRNe incident of this magnitude an extremum was sought to clearly test the limits of the system and identify the needs.

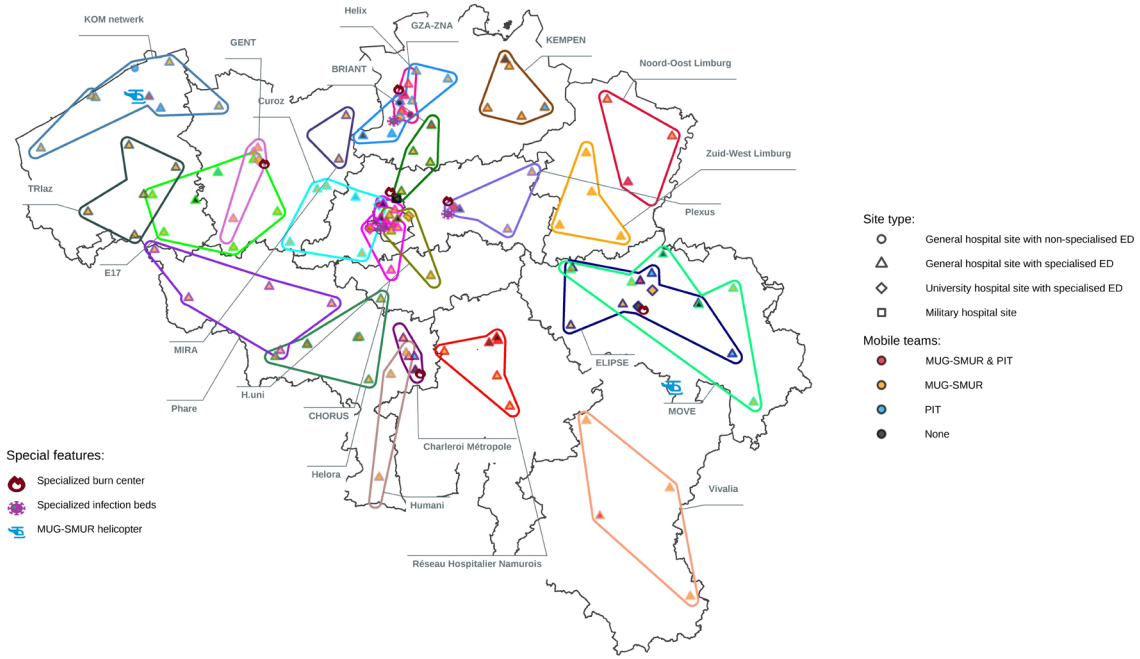
The focus was on the medical management of the incident including all partners (e.g. fire brigade) who contribute to it.

3 CURRENT HOSPITAL LANDSCAPE IN BELGIUM

In 2020, there were 103 general hospitals in Belgium organised across 197 campuses. Among these general hospitals, there were 7 university hospitals representing 6.8% of the total landscape of hospitals. The hospital landscape also includes 17 (16.5%) hospitals with a university character, meaning that they have been allocated a number of beds within a university hospital. [36] The remaining 79 hospitals are general hospitals. There are 14 hospitals in the Brussels region (26 campuses), 52 hospitals in Flanders (96 campuses) and 37 hospitals in Wallonia (75 campuses). In 2021, there were 126 ED in Belgium: 15 for the Brussels region, 46 for Wallonia and 65 for Flanders. Three campuses in Flanders and 1 in the Brussels region have only a '*spoedgevallendienst voor eerste opvang' / 'première prise en charge des urgences'*. The others offer a function for specialized emergency care services ('*diensten voor gespecialiseerde spoedgevallenzorg'/ 'soins urgents spécialisés'*).

The Law of 28 February 2019 plans a maximum of 25 local-regional clinical hospital networks[37] (see Figure 2). Currently there are 24 local-regional clinical hospital networks: 13 composed exclusively of hospitals for the Flemish Region; 8 composed exclusively of hospitals for the Walloon Region and 3 networks for the Brussels-Capital Region.

Figure 2 – Overview of the hospital landscape in Belgium, 2023



When calling the number 112, an operator in the emergency call centre will answer and analyse the request for help. Using the Belgian Manual for Medical Regulation consisting of established protocols, the request for help will be classified into a severity level by the operator that can be assessed by a medical director, a deputy medical director, and nurse regulators. The most appropriate resource (i.e. ambulance, paramedic intervention team (PIT), and/or mobile emergency service (MUG-SMUR)) is called (or the patient is referred to the primary care physician).

Ambulance services

On 18 May 2021, 106 organizations had entered into an agreement "Ambulance service urgent medical assistance" with the FPS Public Health[7]. In this agreement, services undertake to be available at agreed times.

Only services that have concluded an agreement or convention with the FPS Public Health can be called by an emergency centre. An agreement is also a condition for obtaining an allowance from the FPS Public Health. (e.g. assistance zones, organizations and companies recognized by the FPS

Public Health, hospitals, cross associations, others (OCMW-CPAS, airports, etc.) Services without a convention provide non-urgent patient transport or their ambulances can be used as reserve vehicles provided they meet the necessary conditions set by the competent authority. Approximately 75% of the permanence are under roof, which means that the ambulances are on duty and have a rest room at the departure point.

Paramedical intervention teams

There are 33 PITs, of which 24 Paramedical Intervention Teams (PIT) are specifically financed through a pilot project. The PIT team consist of at least one 112-paramedic and a nurse holding the special title in intensive care and emergency care. Indeed, the nurse is entrusted with more tasks than the 112-paramedic through standing orders. This allows the nurse to perform a number of medical acts on the spot. Furthermore, the PIT team has the necessary means of communication to contact a reference doctor if necessary. This is a physician who remotely advises and coaches the nurse in the use of standing orders. They are not necessarily located at a hospital, but most do. Some hospitals have both a MUG-SMUR and a PIT.

MUG-SMUR

There are 84 MUG-SMUR located in hospitals, with a crew consist of at least an emergency physician and a nurse holding the special professional title in intensive care and emergency care The duty station of a MUG-SMUR function is located at a hospital with a function for specialized emergency care service.

There is one CBRNe MUG-SMUR in Belgium, located at the Military Hospital Queen Astrid. The team consist of an emergency physician and a nurse with similar qualifications as the MUG-SMUR above. There are also 3 paramedics. It can only be called by the 112 medical direction of the Brussels dispatching.

A function for specialized emergency care service (‘*diensten voor gespecialiseerde spoegevallenzorg’ / ‘soins urgents spécialisés’*): this service must be permanently staffed by an emergency physician and min. 2 nurses of which at least one nurse who has obtained the special professional title in intensive care and emergency care. This service must be able to stabilize and restore a patient's vital signs.

When a hospital does not has an agreement to host a function for specialised emergency care they can have a ‘*spoedgevallendienst voor eerste opvang’/ ‘première prise en charge des urgences’*: each acute hospital that does not have a specialized emergency department should have an emergency department for primary care. Here, 1 nurse and one physician on duty for the entire hospital is sufficient[38].

In principle, an ambulance transports the patient to the nearest hospital with a specialized emergency care service as determined by the 112 emergency centre. When an MUG-SMUR intervenes, there may also be a deviation from the fastest arrival time based on diagnosis or need for therapeutic platform.

Primary care and public health services

The central 1733 number linked to on-call services is intended for non-urgent medical assistance on weekends or holidays. In half of the municipalities, these calls are also handled through the 112 centre. Trained operators refer the caller, based on the Belgian Manual for Medical Regulation (see below), to the most appropriate care offer. In other municipalities, people are currently redirected to an operator on call or a GP on call. Due to a critical shortage of operators, it is not possible to have calls answered by the emergency switchboard in all municipalities. Based on the Belgian Medical Regulation Manual, the patient is only referred to the general practitioner or duty station when the level is "non-urgent," "mild," or "moderate. From the level serious, very, very bad, the ambulance, PIT or MUG-SMUR is called. In the case of CBRNe incidents, the latter will play a significantly larger role.

4 ORGANISATION OF HOSPITAL EMERGENCY RESPONSE TO A CBRNE INCIDENT

4.1 Enhancing hospital resilience to be prepared for CBRNe events

Hospital resilience is a relatively new concept, introduced in 2011 for which the interest increased with the risk for a disaster to hit hospitals and/or healthcare systems at large. Hospital resilience is unmistakably related to the resilience of the healthcare system. Hospitals are complex organizations using innovative technologies and infrastructures, comprised of, and serving various communities. During disasters, they provide lifesaving emergency care for victims. If hospital preparedness is low, public safety is compromised and the strain on hospital and public health resources increased. Therefore, enhancing hospital resilience aims to maintain the delivery of medical services in a secured and safe way at hospital level, taking into account the position of hospitals within the healthcare system at large.

In this section a conceptual organisational model is proposed to improve resilience of the Belgian hospitals and cope adequately with CBRNe incidents.

4.2 Key principles underlying the organisational model for hospital emergency response to a CBRNe incident

To build an organisational model for hospitals to prepare for and respond to CBRNe incidents, three key principles were taken into account on which the consulted experts agreed.

1. Strengthen what already exists

The experts emphasised that the organisational model should be compatible with the existing structures, processes and expertise regarding disaster management which are working well (e.g. the Medical Intervention Plan MIP), which are situated at different governmental levels and which are defined within the current competences. In terms of hospital organisation, the consulted experts agreed on a hierarchic structure in which different levels of medical CBRNe expertise are organized, formalising the already existing concentration of expertise in certain healthcare services, and hence strengthening what already exists.

2. Prepare all hospitals to react adequately to self-evacuations

Given the geographical distribution of the risk of a CBRNe incident across Belgium, and the problem of self-evacuations in the event of a CBRNe incident, any hospital runs the risk of being confronted with a CBRNe victim. Some hospitals located in densely populated areas (e.g. Brussels) or around chemical industry (i.e. Port of Antwerp with large petrochemical cluster), face even more risk to be confronted with CBRNe victims. Therefore, this proposal advocates giving all hospitals at least the minimum tools to be prepared for an initial response to self-evacuations or self-presenters.

3. Commit to a strong prehospital chain to alleviate the hospital organisation

This report consists of both a prehospital and a hospital component, both of which should be seamless and mutually reinforcing. After all, the prehospital chain and the hospital organisation are like communicating vessels: everything that is not solved prehospital will weigh down the hospital organisation. In line with the organisation of the emergency response in the countries studied, the literature and the consulted experts, the organisational choices made in this report commit to a strong prehospital chain to alleviate the hospital organisation. For example, decontamination of (potentially) contaminated victims is organised at the disaster site to prevent (secondary) contamination of transport vehicles, hospital staff and patients.

4.3 Organisation of hospital emergency response to a CBRNe incident

Based on expert consultation, the already existing concentration of expertise in certain healthcare services and inspired by how the French hospitals are organised to respond to CBRNe events, we propose an organisational model for Belgian hospitals composed of two levels, i.e. type I and type II CBRNe hospitals.

4.3.1 Type I CBRNe hospitals

Type I CBRNe hospitals are charged with the initial and continuing care of severely injured victims with complex care needs relative to C, B and/or RN. Expertise and means should be pooled in these hospitals to be able to accomplish this mission. Type I CBRNe hospitals are few in number and characterised by the highest level of specialisation regarding CBRNe medicine.

In France 12 hospitals are CBRNe reference hospitals, which means they meet the following criteria defined by law: the availability of a mobile emergency service, an ED, an infectious diseases department including negative pressure isolation rooms, a paediatric department, a nuclear medicine department, a laboratory L3 and a helicopter landing area.

The other countries studied (i.e. the UK, the Netherlands, the USA and Norway) are characterized by a decentral approach in which all hospitals must be prepared for initial and continuing care of CBRNe victims. In Norway receiving hospitals can ask for the support of the National Treatment Service for CBRNe Medicine, a university hospital based in Oslo, with cutting-edge expertise in radiation, radiological, biological and chemical injuries. Usually patients stay in the receiving hospital and experts from the National Treatment Service provide the treating physicians with the necessary information and advice remotely. Also in the UK all hospital emergency teams are trained to perform clinical decontamination using personal protective equipment (PPE). Receiving hospitals can consult experts via a single-portal route called Emergency Coordination Of Scientific Advice, where expertise from on-call senior experts across a range of disciplines are available

In the Netherlands not every hospital is equipped to receive heavily injured (i.e. T1) and contaminated victims. Reception facilities for victims of incidents with nuclear, chemical or biological impact are few and far between in the Netherlands. Care for these victims requires specific expertise, which is largely present in the '*Calamiteitenhospitaal'* through cooperation with *the Nationaal Vergiftigingen Informatie Centrum* (NVIC), part of the *Rijksinstituut voor Volksgezondheid en Milieu* (RIVM). The '*Calamiteitenhospitaal'* is however not a reference hospital. It is only activated in case of a potential imbalance between care need and supply in Dutch regional hospitals. After decontamination and stabilization in the '*Calamiteitenhospitaal'*, patients are referred to a hospital in their neighbourhood (i.e. within 5 days).

Based on the requirements of the French reference hospitals and the conclusions from our expert consultation, we propose that hospitals should have access to the following requirements for type I CBRNe hospitals, in addition to the requirements for type II CBRNe hospitals which are described in the next paragraph:

1. **the presence of C, B or RN-related medical expertise organised in a supra-hospital network**

The experts in CBRNe medicine working in type I CBRNe hospitals could be organised in a supra-hospital network of medical expert-advisors on dangerous substances who are 24/7 on call. In addition to their advisory function in case of a CBRNe incident, also the type II CBRNe hospitals could call on them, e.g. in the case of self-evacuation or in the event of a single person presenting at an ED who had a small-scale CBRNe accident in the private or work context.

2. the presence of decontamination infrastructure for victims in lying position

Providing decontamination capacity in type I CBRNe hospitals seems contrary to the basic principle that decontamination is done at the disaster site. However, according to the experts consulted there can be a deviation from this principle for a small number (e.g. n < 5) of severely injured victims (T1) who are transported to a type I CBRNe hospital after minimal decontamination (e.g. in MARCHE2 protocol rapid spot decontamination). Therefore, a small number of hospitals should be able to do wet decontamination of a severely injured patient lying down. In addition, small accidents (hence outside the context of a mass casualty incident) leading to one or few contaminated victims must also be taken care of.

3. the presence of the following departments/specialisations

- Reference centre for severely burned patients
- Major trauma centre
- Haematology department (with positive pressure rooms)
- Nuclear medicine department
- Lab for toxic substances
- Infectiology department (with negative pressure rooms)

These specialisations were mentioned by the consulted experts as specialisations essential in a CBRNe type I hospital for both initial care and continuing care of severely injured victims of a CBRNe incident.

4. the availability of protective clothing and medical staff trained to function in this protective equipment

Type I CBRNe hospitals must have a stock of personal protective equipment (PPE) and trained staff. The amount and type of PPE depends on the local organisation of ED (e.g. number of teams). Regular training of health staff is a major investment and is challenging in terms of staff turnover and releasing staff for this purpose.

5. the availability of a decentral rotating stock of antidotes/medication/PPE

The experts consulted confirmed the need for a detailed plan for stockpiling, distribution and fast mobilization of antidotes towards the contaminated patients, as was also mentioned in the report of the Belgian Superior Health Council of 2019.[16] Type I CBRNe could also house a decentralised national rotating stock of antidotes/medication/PPE in function of the CBRNe risks present in their area. Antidotes are useful both in daily care and disasters. By stocking them in type I CBRNe hospitals they are timely available for use in all hospitals, in hospital-networks, and at the field.. The experts consulted suggested to share the decentralized national stock of antidotes with Seveso companies (e.g. through service level agreements), and to integrate the availabilities into the existing system of data registration such as the Incident and Crisis Management System (ICMS)/PARAGON.

6. the availability of a CBRNe MUG-SMUR (optional)

Type I CBRNe hospitals could be the base of operations for CBRNe MUG-SMUR (see section 5.2).

4.3.2 Type II CBRNe hospitals

It cannot be excluded that one or more contaminated patients (mainly T2 and/or T3) arrive at the ED of a hospital (i.e. self-presenters, self-evacuation). In addition, even in case decontamination was done on site, residual contamination remains a point of attention. Type II CBRNe hospitals should be able to take care of self-evacuations resulting from a CBRNe incident, as well as victims who do not require complex continuing care after decontamination in the field or in a type I CBRNe hospital. After decontamination, if no CBRNe specific treatments are needed, CBRNe victims most often become a regular trauma and/or burn patient. A victim is no longer a CBRNe victim, once he/she no longer puts other people at risk of (secondary) contamination.

What is described below for type II CBRNe hospitals also accounts for type I CBRNe hospitals. It is a basic package of requirements all hospitals should take into account.

Type II CBRNe hospitals could also function **as surge capacity for the type I** CBRNe **hospitals**, on the condition of **guidance by the medical expert-advisors** located at the type I CBRNe hospitals. Any type II CBRNe hospital should be able to rely on the medical CBRNe expert-advisors located in type I CBRNe hospitals (see below: section 4.4). To respond adequately in the event of self-evacuations, the type II CBRNe hospitals need an **emergency procedure** whereby they can lock down and protect their infrastructure, staff and patients while continuing their regular service provision.

Type II CBRNe hospitals need to be able to **receive patients outside their buildings, carry out minimal decontamination** (e.g. removing clothing and putting on emergency clothes) following the right procedures for undressing or at least supervise whether undressing is done the right way to be sure rest contamination is minimal. Therefore the healthcare providers need PPE and be able to function in PPE. Type II CBRNe hospitals do not need to have a fixed decontamination infrastructure inside, but rather a procedure whereby victims can be decontaminated outside, either by their own decontamination means (e.g. a simple water hose connection outside with hot water (32-35°C) and separate drain for waste water), or by a mobile decontamination unit that is on call (e.g. through agreements with the fire brigade), or by transport (e.g. by bus) to a staging area where decontamination is carried out.

Type II CBRNe hospitals need to focus mainly on **'awareness'** among medical and support (e.g. reception) staff so that they can recognise a contaminated patient in time. People may start feeling sick after they returned home, and decide to visit the ED of a type II CBRNe hospital. The importance of awareness among medical staff was also addressed in the report of the Belgian Superior Health Council of 2019.[16]

Type II CBRNe hospitals need a **minimum supply of PPE and staff who can work with it**. An alternative could be for a CBRNe MUG-SMUR to arrive on the hospital site to support the hospital staff and thus ease the investment for type II CBRNe hospitals, to the extent that the CBRNe MUG-SMUR(s) is/are not already deployed at the disaster site.

4.3.3 Hospitals at increased risk of self-evacuations

Any hospital can face self-evacuations or self-presenters. However, some hospitals are more at risk than others due to their location near CBRNe hazards (e.g. chemical industry, nuclear power plant) and in an area with high population density (e.g. metropolitan context). It can be expected that if a CBRNe incident occurs in the immediate vicinity of such a hospital, victims who are not severely injured, will make their way to the nearest hospital on their own. Hospitals at high risk of such self-evacuation should be prepared for a large and rapid influx of potentially contaminated lightly injured patients.

To avoid secondary contamination of hospital infrastructure, staff and patients, hospitals need to assure that contaminated patients are decontaminated before entering the hospital. In Belgium, the reception and waiting room of hospital ED's are freely accessible. Experts consulted suggested to increase public awareness to prevent self-presenters to walk in, and to attach a signpost at the ED entrance to warn self-presenters and ask them to wait outside and call for help. In addition, in case of a large-scale CBRNe incident, hospitals should be informed immediately, so that they can prepare for self-evacuation. This way doors can be closed or guarded to avoid contaminated patients to come in and standard operational procedure (SOP) for decontamination can be initiated.

Therefore the following requirements are relevant on top of the type II CBRNe hospital requirements. An **extensive hospital emergency plan (HEP)**, including decontamination SOP and agreements with for example the fire brigade and civil protection service could be aimed at to assure the processes and support needed to handle a large and rapid influx of victims. Elements to be considered as part of the decontamination SOP are for example designation of personnel responsibilities, upscaling and rotation of personnel, the available types and location of PPE, decontamination equipment, detectors, antidotes, and emergency clothing for the victims, and the designation of a separate entrance for regular patients. Also agreements made with other organisations outside the hospital such as hospital network agreements (e.g. concerning staff, supply, expertise) or agreements with the

fire department (e.g. for decontamination) should be described in the SOP for handling contaminated and/or infected victims.

In addition, **a large area outside** (e.g. a parking area) is needed to receive contaminated victims and keep them separate from non-contaminated patients (including regular patients visiting the ED. These hospitals could build **expert knowledge** and infrastructure in function of **crowd control** and responding to the type of dangerous agents present in the immediate surroundings of the hospital. These hospitals with an increased self-evacuation risk mostly differ from the other type II CBRNe hospitals in degree, rather than in kind, which means that they mostly need more capacity to receive potentially contaminated lightly injured patients.

4.3.4 Transfers between type I and type II CBRNe hospitals

After decontamination on the disaster site, CBRNe victims are transferred to a type I CBRNe hospital. However, after the acute phase in which treatment was started, and if the treatment no longer requires medical expertise related to C, B or RN, a referral to a type II CBRNe hospital can be considered.

4.4 Preconditions to the organisation of hospital emergency response to a CBRNe incident

4.4.1 Integration of a CBRNe section in hospital emergency plans

Planning is essential in order to be (better) prepared for plausible disasters). In 2016, Belgium undertook actions such as the national rollout of HEP[39] and in 2018, the development of a manual on CBRNe emergencies.[40] By mid-2022, more than 90% of the hospitals submitted their hospital emergency plan. Meanwhile a working group of the federal public service is updating the hospital emergency plan template. Note that the procedure to submit follows a trajectory along different governance levels and while the Federal public Service (FPS) Public Health is actualizing the HEP, authorization of the plans is under the competence of the federated entities.

With the information provided in this section we aim to nourish the CBRNe section of the hospital emergency plan template. Based on the key person interviews, the following principles should be taken into account.

1. Hospital emergency planning for CBRNe emergencies should be a collaborative process

During the key person interviews, interviewees expressed the need for coordination between hospital emergency plans. Hospital emergency plans seem to be developed in isolation, while a certain degree of coordination between emergency plans of several hospitals could be useful with regard to CBRNe. Therefore the role of every hospital, within hospital networks, but also on a regional and national level, should be clearly defined, which is not the case now. Hospital emergency plans should be compatible with each other and with the other emergency and intervention plans (e.g. MIP). In addition, SOP could be specifically useful to be created at a supra-hospital level (e.g. hospital network level). It is preferred to align the SOP related to CBRNe emergencies as much as possible across hospitals (e.g. within hospital networks). For example, it would be useful to align the SOP for decontamination in hospitals with the decontamination procedures as specified in the CBRNe section of the MIP, which is yet non-existent.

2. Hospital emergency plans should be aligned with the role of each hospital in the CBRNe preparedness of the healthcare system

In 2018 a manual focussed on CBRNe has been developed to help hospitals with designing their HEP. However, the key persons we interviewed evaluated the manual as too little operational and too focussed on clinical aspects, instead of on emergency planning as such. In addition, interviewees reported that what is asked theoretically in the HEP template, is not always feasible in practice and the regulatory framework was said to be unclear. Each hospital needs to know which role it is expected to take up and what the minimum criteria are to fulfill that role (e.g. norms for infrastructure).[27] Interviewees asked to make expectations explicit, outline them in SOP and legislation, and to support and endorse them with funding. Since, hospitals do not receive a specific budget to spend on CBRNe preparedness, their investment in CBRNe preparedness is left to their own initiative based on their risk assessment and possible partnerships with

companies located in the vicinity of the hospital. For example the function of emergency planning coordinator is mandatory[41, 42] but hospitals have to fund it with their own budget, hence decide for how many hours the coordinator is appointed, as the law does not foresee any funding.

3. There is a need for operational translation in order to make the paper plans work

The operational translation of the 'paper' HEP is elementary for a 'paper' plan's ability to work in practice. This can be attained by training, informing, educating, exercising, cultivating an awareness culture and endorsement at all governance levels including the hospital management, the regional and federal authorities.[27] The 'paper' plan needs to be tried out and practised, and lessons should be learned on what goes good / wrong, to subsequently improve the plan.

4. Hospital emergency planning should follow a dynamic process

Planning should follow a dynamic process (as it evolves continuously and should be updated according to the lessons learned). The interviewees made clear that feedback and follow-up of the hospital emergency plan is missing.

5. Early planning is essential for structural and infrastructural resilience

Planning should be done as early as possible. Structural resilience involves the need for safe and accessible hospitals such as designing safe access routes, equipped ambulances, helicopter landing, but also constructive elements such as designing open spaces, renovation of hospitals, indicating hazards maps, designing an area for decontamination in case of self-evacuation, foreseeing a separate entry for contaminated patients, etc. [21, 27] Early planning is also important in function of infrastructural resilience and to preserve lifeline facilities (e.g. safety water tanks, food, fuel, communication devices, medical gases) against for example (cyber) terrorist attacks. When hospitals plan to renovate, redesign or build new hospital sites, policy makers and architects should take the needed (infra)structural elements related to CBRNe emergencies into consideration. With the 6th state reform, funding for hospital infrastructure shifted to the federated entities.(see section 5.3.5)

6. A hospital emergency plan should be based on a risk assessment

Following Khalil et al. [43], the first step of emergency disaster management and hospital resilience is risk assessment. Risk assessment includes identifying hazards, exposures, vulnerabilities (at the facility and community levels), along with capacity assessment and impact analysis. Risk analysis is a critical tool and the first step toward awareness which has been described as a key attribute and competency of resilience. Building on emergency and disaster risk assessment, hospitals must prioritize their risks and plan accordingly. Resilient hospitals require strategies to prevent and mitigate hazards, reduce vulnerabilities and assess overall disaster risks with proactive all hazards hospital emergency plans.[43]

7. A hospital emergency plan should include standard operating procedures

We observed a large variability in the elaboration of the CBRNe section of the HEP and the development of the SOP were observed. SOP give a clear direction to the operationalization of the HEP. The updated HEP template should provide directions regarding the SOP that should be included. For example, to facilitate timely response, strategies endorsing role uptake should be described and operationalized (SOP for role uptake) (e.g. the use of role cards).[27, 30]

To standardize the quality of care delivered, **a SOP for management of patients** should be foreseen. Patient management includes admission or referral, triage, diagnosis, treatment, patient flow and tracking, discharge, and follow-up as well as the management of support services, pharmacy services, and logistics and supply functions. In literature two elements were specifically highlighted: patient tracking, and a protocol for triage. Within this SOP, a specific procedure for the tracking and follow-up of patients should be foreseen (see section 5.3.4). Also an appropriate triage protocol adjusted to the agent (CBRNe) and applicable classification schemes and the target group (e.g. vulnerable groups such as elderly, pregnant women and children)

To maintain safety and security, several SOP should be foreseen.

- **A SOP for waste management**. Contingency plans are necessary for managing hospital waste as well as the wase generated in CBRNe events (e.g. decontamination waste water, PPE,..) as it could lead to secondary contamination and disasters negatively affecting humans and the environment.
- **A SOP for morgue management**. Inadequate morgue facilities and dead body handling that may be contagious, increases the risk of (secondary) contagion. Therefore, adequate morgue capacity, temporary morgue speace, refrigerated storage facilities, and trained staff are essential to ensure proper identification and disposal, and to reduce the risk of transmission.
- **A SOP for logistic management**. Procedures towards collection, labeling, packaging, handling, transport, etc. of hazardous materials is necessary.
- **A SOP for handling contaminated and/or infected victims.** This is crucial for CBRNe and should be a key focus**.** As this SOP relates to the future directions proposed in this report, it is described in detail in section. The interviewees indicated that the greatest challenge in the blister agent scenario (late detection) was dealing with secondary contamination inside the hospital, but also inside ambulances.
- **A SOP for capacity related to space, staff and stuff.** Preventing capacity overload at any one hospital is a primary goal mentioned by the interviewees. In literature, capacity is conceived to be a key element as the World Health Organisation (WHO) stipulated: *to ensure the safety of lives, hospitals and health care facilities must remain safe, accessible and functioning at maximum capacity during emergencies or disasters*. To tackle potential strains on capacity, considering a high influx of victims, literature indicates the necessity of sharing resources in the adequate allocation of scarce resources. Towards 'resources', the main attention is drawn on sharing support for 'space' capacity, 'stuff' capacity, and 'staff' capacity.
- **A SOP for communication and information.** This SOP is needed for several reasons such as maitaining communication with other hospitals, inside the hospital, with the authorities and the public. More information on the content is outlined in the section 5.3.4.
- **A SOP for training.** This is needed to enhance awareness, earn competencies, endorse collaboration, etc. It is described in the section 5.3.2.

4.4.2 Enhancing hospital workforce

4.4.2.1 Exercise and training capacity of D2 should be increased

CBRNe events do not occur regularly. By consequence medical emergency responders (D2) and ED staff have few opportunities to build experience. Therefore continuous learning by means of training courses and disaster drills is essential to keep skills and knowledge up to date. For example, emergency responders should be regularly trained in the safe and effective use of PPE, decontamination procedures, and triage. However, the consulted experts pointed out that the medical discipline (D2) has little training capacity compared to the other disciplines. It is difficult to free up ED staff for trainings and drills, because of understaffing and turnover. Trainings outside working hours are often on a voluntary basis for physicians (with self-employed status). Participation in trainings and drills is mostly based on goodwill and intrinsic motivation. Moreover, when support from the hospital falls short, people get discouraged (e.g. training to put on PPE is useless if no PPE is available in the organization). Working under CBRNe conditions (e.g. wearing PPE) is however particularly burdensome and stressful. Regular trainings and disaster drills (e.g. field simulations, simulations using digital technology, etc.) are needed to increase the experience and skills of emergency responders to cope with very stressful working conditions.

Treatment of CBRNe victims requires large numbers of care providers due to the need to wear PPE and thus the personnel can only work for a limited period before they have to be rotated out. Healthcare workers need to be familiar with working in PPE whilst following safety procedures and being exposed to high levels of physical discomfort and psychological stress. The experts consulted – confirmed by the scientific literature[15, 44] – pointed to the need for medical staff to train more frequently whilst wearing PPEs.

At hospital level, training programs should include at least three subcategories: increase knowledge, increase awareness and increase skills.[18, 25, 45] A regular training plan that allows the staff involved in emergency situations to exercise their roles should prepare and empower them to take up their roles at the event of a CBRNe emergency. It should be taken into account that it is necessary to repeat technical training periodically, usually within 6-9 months to maintain skills.

Preparation of and participation in disaster drills is laid down in the Belgian legislation. The RD of 16 February 2006 concerning emergency and intervention plans stipulates the obligation to exercise (Art.26, 7°) and the organization and evaluation of exercises (Art. 29 §2, 2° and 3°).[46] The RD of 16 February 2006 has been repealed and replaced by the RD of 22 May 2019. The RD of 22 May 2019 on emergency planning and emergency management at the municipal and provincial levels specifies the role of mayors and provincial governors in the event of crisis events and situations requiring coordination or management at the national level. These local and provincial authorities are responsible for the organization of multidisciplinary exercises, regularly and at least once a year to test emergency plans, determine the modalities and frequency of the exercises, establish an exercise calendar and include them in the national security platform. They must also evaluate exercises and real emergencies and adjust the existing emergency plan accordingly (Art. 3 §2 5° and 6°).[47] In addition, they must make sure that hospitals within their province or municipality test their HEP every year. HEP should contain a multi-annual plan for exercises to validate or adapt the HEP. Each hospital has to plan at least one exercise per year, with a systematic debriefing and an adaptation of the plan to ensure its adequacy. Also in the MIP the need for regular participation in mono- and multidisciplinary exercises is encouraged.

Hence, in the legislation the need for training and drills is recognised but criteria for assessing the quality and the relevance of the field exercises are unknown. Neither does legislation foresee funding for the organization of exercises, nor have rules been established for the organization and/or evaluation of these exercises. As a result, there is great variation between provinces in both the number and quality of exercises. Finally, exercises cannot be prepared by the participants of the exercise, as the unexpected character is important to allow learning. Hence the workload of the preparations should not be underestimated either. The Federal Health Inspection is involved in the set up and preparation of disaster exercises, but is understaffed.

4.4.2.2 Awareness and expertise among receptionists of emergency departments should be developed.

CBRNe incidents occur too little to develop a sensitivity for CBRNe. At hospitals, the receptionist at the ED plays an essential role in early warning. If a single person signs up at the ED, the receptionist or triage nurse should be able to detect whether the person is a contaminated CBRNe victim to avoid contamination of the ED. Hence, every hospital should have receptionists at the ED trained to recognize symptoms by observation only.

In the USA receptionists survey patients before they enter the ED. In Belgium, for single presenters, ED's are often freely accessible. If a general practitioner refers a potentially contaminated patient to the ED, he should warn the hospital before arrival of the patient. This way the receiving hospital can activate the necessary procedures for the reception of possibly contaminated patients. As done in the UK, many templates can be used with pictures illustrating victims and key symptoms. A SOP enhancing awareness and recognition of these victims could be added to the hospital emergency plan.

5 ORGANISATION OF PREHOSPITAL EMERGENCY RESPONSE TO A CBRNE INCIDENT

5.1 Key principles underlying the organisational model for prehospital emergency response to a CBRNe incident

The response to major CBRNe incidents is informed by a vast body of scientific research regarding all aspects of emergency response to a CBRNe incident in general and on mass casualty decontamination in particular, as the latter is specific for CBRNe, is essential in saving lives and is very demanding in terms of staff and equipment. Below we outline the key principles for which there is research evidence and on which the proposed organisation of prehospital emergency response to a CBRNe event in Belgium is based.

1. Incident recognition and rapidity of the response is crucial

Precondition to an effective incident response is the recognition that actual or potential exposure to a hazardous material has occurred.[48] Adequate training and exercising of first responders are vital in facilitating incident recognition. Health effects in several persons (e.g. three or more in close proximity) may be the first indication of a mass casualty event. A relatively small group of chemicals have characteristic toxidromes, but the vast majority of hazardous materials cause non-specific effects such as coughing, headache, nausea, vomiting, diarrhoea and dizziness.[48]

The delay in the deployment of specialist resources has significant health consequences for exposed victims, especially in case of certain chemical agents with a rapid onset of reaction, such as hydrogen cyanide or nerve agents.[49] In addition, waiting for specialist resources to arrive also increases the risk of large numbers of potentially contaminated victims presenting themselves at healthcare facilities. Research has been done on issues relating to the rapidity of the response and the optimisation of the decontamination process. For example one of the outcomes of the ORCHID (Optimisation through Research of Chemical Incident Decontamination Systems) projects, led by Public Health England, was that the rapidity of the UK response model needed improvement to maximise the use of time during the earliest phases of an incident. Subsequently the UK adopted a new decontamination strategy and introduced an emergency disrobe and decontamination stage prior to the arrival of mass decontamination units.[49]

Until 2006, the UK response for decontamination was for first responders to stand off and wait for specialist resources to arrive in case of three or more victims. The arrival time of specialist resources in the UK may be up to one hour. The updated model was named the Initial Operational Response (IOR) model and consists of emergency personnel to start with disrobing victims to remove potentially contaminated clothing, and improvised dry or wet decontamination with any readily available absorbent materials and water if necessary. After improvised decontamination, interim decontamination would be conducted, using fire and rescue service vehicles to create a shower corridor through which victims are showered using hoses (also known as the 'Ladder Pipe' system in the USA). This updated model significantly reduces the time between exposure and intervention.[50] The USA moved to a similar approach focussing on rapid intervention, including disrobing and improvised decontamination, informed by scientific evidence that rapid improvised decontamination is preferable to waiting for specialised resources to arrive.[51] Also in the Norwegian response model the 'Ladder Pipe' system is described.[52]

2. Disrobing casualties is necessary

The removal of clothing following chemical exposure is widely recognised as an appropriate early intervention to prevent penetration of the chemical to the skin and secondary contamination, including of emergency staff. There does not appear to be any hard scientific evidence for the figure of 80-90% removal of contamination after disrobing. It is rather based on the

rule of nines[53b] and the assumption that all areas of the body except the hands and face are covered in relatively impermeable clothing. Regardless of the percentage of hazardous product removed, disrobing is an effective and practical way of reducing exposure to hazardous products.[48] It is essential that disrobing is performed as soon as possible, especially in case of liquid contaminants for which it is shown that the effectiveness of disrobing rapidly decreases with time due to diffusion of the contaminant through the fabric layers.[48, 51] Note that consideration should also be given to forensic requirements e.g. plastic bags need to be available for storage of decontaminated clothing in line with the SOP 'waste' management to be integrated in the hospital emergency plan.

In the UK and USA, emergency disrobing is part of the Initial Operational Response (IOR) model. It is recommended within 15 minutes of exposure, but responders should also consider the risk of hypothermia, as well as modesty concerns by using emergency clothing or blankets.[50] In France, packs with emergency clothing are part of the equipment of the mobile health units (*postes sanitaires mobiles* PSM 1 and 2).

3. Multiple decontamination interventions performed in sequence are preferrable to a single decontamination intervention

Recent studies[54, 55] concluded that combining dry, wet and/or improvised decontamination was more effective at removing the contaminant than when conducting only one decontamination intervention. Also the risk of secondary contamination was reduced. Decontamination is therefore recommended to be a sequential process starting with improvised decontamination forms, through to specialised decontamination. One intervention alone is not sufficient.[54]

[b] The rule of nines is an estimation of body surface based on assigning percentages to different body areas, e.g. the entire head is estimated as 9% of the body surface.

4. Victim focused decontamination facilitates compliance

Studies have examined how to facilitate public compliance in case of an incident with (potential) exposure to hazardous materials. Effective and honest communication and demonstrating respect for the victim's specific needs came out as key actions. Not all CBRNe victims have the physical or cognitive ability to comply with decontamination instructions or procedures in response to exposure to hazardous products. Examples of factors inherent to the general population which may potentially reduce the ability of emergency staff to respond are young age, old age, dementia, religion, language, pre-existing disability or other medical conditions, and incident-related injury.[56, 57] Hence responders should receive training and guidance for managing members of vulnerable groups. For example, compliance with decontamination procedures will be increased when casualties' privacy is respected, even if it is not possible to provide them with as much privacy as they would like. In that case the reasons for the lack of privacy could be explained (e.g. in pre-incident information to the public).[54]

5.2 Organisation of prehospital emergency response to a CBRNe incident

5.2.1 How to bring medical expertise in CBRNe and specialized equipment to the disaster site

For the triage, stabilisation (e.g. provision of Advanced Life Support (ALS) to contaminated victims) and decontamination of contaminated victims medical expertise and specialized material (e.g. protective clothing, medication, antidotes) are needed on the disaster site. In addition, the setting up of a decontamination site requires a command structure that is not familiar to hospital staff. Having a hospital incident leader to coordinate the triage and decontamination process as well as staff rotation is recommended in the literature.[44] The hospital staff should primarily be

focused on treating the patients and not be distracted by the setting up of the pre-hospital decontamination facilities. Trained and qualified triage personnel is needed to determine the priority of treatment and decontamination.[58]

The question is how these roles can be fulfilled in an efficient way which is consistent with the current make-up of the Belgian disaster management system. From our expert consultation 2 scenario's emerged.

Scenario 1: Multiplication of specialised mobile emergency services (CBRNe MUG-SMUR)

In Belgium, medical expertise and specialized equipment is currently brought to the disaster site by a specialized mobile emergency service (CBRNe MUG-SMUR) staffed and equipped for that purpose. Currently one such a CBRNE MUG-SMUR is available in Belgium. It is located at the Military Hospital Queen Astrid (MHQA) in Brussels and consists of a MUG-SMUR (one emergency doctor and one emergency nurse) and an ambulance carrying specialized equipment for an intervention in a CBRNe context (3 paramedics). It is called via the Dispatching 112, with a triage by the Dispatching 112 of Brussels. On site they provide Advanced Life Support (ALS, i.e. MARCHE²) to contaminated victims.

Since a short response time is essential, consideration should be given to how several such teams could be installed and how many are needed. The possibility defended by a large part of the experts consulted is to increase the number of CBRNe MUG-SMUR(s) to cover the Belgian territory and in function of the concentration of CBRNe risks, without specifying the precise number (e.g. one CBRNe MUG-SMUR per type I CBRNe hospital). In France and the UK similar strategies of bringing trained staff and material to the disaster site are implemented.

- In France, the mobile health units (p*ostes sanitaires mobiles PSM 1 PSM 2*) constitute the tactical stocks. The main mission of the PSM is to reinforce the emergency medical aid for the prehospital care of victims (in the framework of an emergency plan "ORSEC-NOVI"). PSM can also reinforce the stocks of hospitals when a HEP is activated. They contain health products (e.g. medicines, antidotes, medical devices, medical-surgical equipment) and logistic material (e.g. tent, power generator). There are two types of PSM with different capacities: PSM 2 allows to take care of approximately 500 victims during about 24 hours. Twenty four PSM 2 cover the French territory and are located at University hospitals. PSM 1 are of a smaller size, allowing the management of 25 victims during about 24 hours. Ninety five PSM 1 are spread over the country and are located at emergency medical services (*service d'aide médicale urgente* SAMU). The latter take care of the regulation of medical emergencies for a specific health region, they receive the requests for urgent medical assistance and send out the resources needed. Regarding antidotes capacity there are 2 boxes available in PSM 1 and 4 boxes in PSM 2, with 1 box serving 15 victims.
- In UK, Hazardous Area Response Teams (HART) are trained by the National Ambulance Resilience Unit (NARU). HART is comprised of paramedics who are trained and equipped to provide the ambulance response to high-risk environments and complex emergency situations. Together with fire and rescue services HART work in the hot zone of a major incident. Their job is to triage and treat casualties and to help save lives in very difficult circumstances. At least one HART unit is available in each of the 10 NHS ambulance trusts of England. HART can work together across the country. They work in 12 hour shifts on a seven week rota of which one week is devoted to training. Hence, HART staff trains on an ongoing basis.

CBRNe MUG-SMUR could be **embedded in CBRNe Type I hospitals** (similarly the PSM 2 are based at University hospitals in France) if these are geographically spread over the territory in function of the concentration of CBRNe risks. Although CBRNe MUG-SMUR staff would then not be exempted from their tasks at the ED, they could spend part of their time on training and providing training and coaching to CBRNe type II hospitals. The UK HART, for example, have a rotation system that allows them to devote one week out of seven on training.

Alternatively the CBRNe MUG-SMUR could be conceived as **a standalone service**. In the latter case, the team could be exempted from other tasks (e.g. work at a hospital) in order to spend all of their time on training and

providing training and coaching to hospitals' staff on demand. These mobile CBRNe medical teams could also assist other hospitals in case of an event (similar to PSM in France).

A disadvantage of the multiplication of CBRNe MUG-SMUR scenario is its high cost, which consists mostly of keeping medical staff trained and 24/7 standby against the background of the low frequency of CBRNe incidents.

Scenario 2 - Separate supply of medical expertise and specialized material by different actors

An alternative to the multiplication of CBRNe MUG-SMURs scenario could be to decouple the medical expertise needed to do the triage and stabilization of contaminated patients from D2 (medical discipline) and shift it to D1 (fire department).

The medical expertise needed for triage and stabilization on site includes mostly the administration of pain medication, stopping massive bleeding, the clearing of airways, and carrying out dry and/or spot decontamination. If these tasks can be done by an ambulance nurse, physicians might not be needed on site at this stage, but can be standby in back office in case specific medical expertise is needed. This means ambulance nurses of the fire brigade could be send out by the Dispatching 112. Usually they have a short response time and they are trained to work in protective clothing. The specialized equipment could be supplied by the civil protection service or the First Intervention teams (*Snelle Interventie Teams* SIT – *First Intervention Teams* FIT) of the Belgian Red Cross. One SIT-FIT consists of a SIT-FIT MED (medical products such as oxygen) and a SIT-FIT LOG (equipment): it carries the material to handle 10 victims (in non-CBRNE accidents).

This way medical expertise and the specialized material are supplied by two different actors and with different transportation means. However, the feasibility of this approach is questionable. Especially the medical expertise inside D1 and the response time of the civil protection and of the Red Cross (which operates on a voluntary basis) seem potential problems. Also if the response time of the decontamination unit of the civil protection service stays two hours, D1 has to manage triage and stabilisation all by itself during two hours without the support of D2 on site, except for remote advice or guidance (e.g. by means of body cams). Alternatively the decontamination unit of the civil protection service should be faster on site. In addition, this scenario does not solve the problem of medical expertise needed to assist during wet decontamination of injured victims (see section 5.2.2).

5.2.2 How to organize decontamination at the disaster site

For the organisation of decontamination we departed from the key principles outlined above, which are based on the scientific literature, country information and expert consultation.

The international literature demonstrated that the decontamination of contaminated victims should happen as soon as possible to save the life and health of contaminated persons and minimize the risk of secondary contamination. Although there is a broad consensus that decontamination should be carried out as quickly as possible [16], individual countries translated this into different procedures and ways of putting it into practice.[59] Decontamination is generally performed on-site in the warm zone after evacuation from the hot zone. Note that in a small number of countries (e.g. Israel) casualties are immediately transported to hospitals with decontamination facilities. In theory, hospital or on-scene decontamination have relative advantages and disadvantages, but there is no evidence to state that one is performing better than the other.[48] The performance of decontamination on-site flows from the importance of the rapidity of the decontamination (see key principles), the prevention of secondary contamination (for ambulance and emergency workers), and the difficulties in transporting contaminated victims (e.g. requirement of additional protective measures, contamination of the vehicle).

We looked at the decontamination protocols of Norway, the Netherlands, France, the UK and the USA. In all countries, the general approach is to decontaminate as quickly as possible on the disaster site before transporting victims to a hospital, which is in line with our first key principle.

- In **Norway,** the fire and rescue services are responsible for the immediate evacuation of persons out of the hot zone. Then they establish a decontamination area on the border between the warm and cold zone. Healthcare personnel from the ambulance service receives evacuated patients in the warm zone, assesses their clinical status and provides immediate life-saving treatment. The extent of contamination is assessed and patients are triaged. The critically ill (i.e. T1 victims, in need of medical treatment within one hour) receive minimal decontamination (i.e. dry decontamination) and are immediately transported to the ED of a hospital. Other victims (T2 and T3) are disrobed following the evidence-based procedures, receive emergency clothing, and are transported to the ED or wet decontamination on site is carried out if deemed appropriate (e.g. in case of spores, toxins or radiation contamination). Decontamination of persons without a need for medical treatment is not a task for healthcare personnel, but is carried out by the fire and rescue services or civil security services. People can also be asked to go home, undress outdoors and shower in their own house.
- In the **UK,** the general principle is that both injured and uninjured casualties who are suspected of being contaminated receive decontamination at the scene.[60] When people are capable of removing their own clothing and decontaminating themselves, they should do so under supervision.[60] The careful removal of contaminated clothing is considered a priority and should be carried out as quickly as possible. To save time, improvised or emergency decontamination is done: i.e. the use of immediately available methods to decontaminate casualties initiated by the first responder at the earliest opportunity.[61] In the UK dry decontamination is used as the default intervention for anyone that is suspected of being contaminated unless there are obvious signs of burning, skin irritation or the contaminant is known to be either biological or radiological. Wet decontamination is recommended to be used if contamination with a chemical substance that causes irritation or burning sensations, is suspected, or if the contaminant is known to be either a biological or radiological agent. Improvised or emergency decontamination should continue until more structured interventions are present. The IOR model with disrobe and emergency decontamination while awaiting specialist response, is developed specifically for ambulant casualties, i.e. individuals who can both understand instructions an perform self-decontamination with minimal assistance. Protocols for non-ambulant decontamination are in the pipeline.[62] The fire and rescue services are equipped with mobile mass decontamination units, including disrobe- and re-robe packs. The decision on when to use mass decontamination will be taken by the ambulance service in consultation with the Senior Fire Officer and co-ordinating police commander.[60]
- In **the Netherlands**, for every victim disrobing is the first step in the decontamination procedure and this is done at the border of the hotzone.[63] For gas and vapour contamination mostly disrobing is considered sufficient. For solid-state contamination the medical expert-advisor hazardous materials (*Gezondheidsadviseur gevaarlijke stoffen* GAGS) decides whether wet decontamination is needed. For liquid contamination, dry decontamination needs to be followed by a wet decontamination if wet decontamination is feasible. T1 victims who might not survive wet decontamination, can be treated by medical staff in PPE and transported by ambulance after dry decontamination only. In the Netherlands not every hospital can receive a contaminated T1 victim, as not every hospital is equipped with the necessary decontamination facilities. At arrival at the hospital the ambulance staff transfers information to the hospital staff regarding the nature of the incident and the decontamination carried out on the disaster site. The GAGS proactively contacts the hospitals to pass on product information. After wet decontamination, the victim receives substitute clothing and is transferred to ambulance care in the cold zone.

In line with the literature and the decontamination procedures in other countries, several interviewees emphasized the importance of decontamination at the site of the accident, before the victim comes into contact with the medical care chain. Also in the current CBRNe manual for hospital emergency planning the general point of departure is that victims must be decontaminated before any medical treatment.[40]

For **T1 victims** a fast partial decontamination[c] is proposed in the manual, after which the intervener (wearing PPE) can proceed to advanced life support. We concluded that in line with the decontamination protocols of the countries studied and the expert consultation that for victims who are life-threateningly injured (i.e. T1) and run the risk of not surviving (waiting for) wet decontamination, advanced life support (following the principle 'treat first what kills first') and dry decontamination on site are recommended and should be followed by immediate transport to the nearest type I CBRNe hospital. At the type I CBRNe hospital there should be an established decontamination infrastructure in place that is operational and equipped to decontaminate a seriously injured victim lying down, as well as the expertise and medical staff to do so, while the ED must stay up and running for regular patients. Some of the consulted experts hinted that this decontamination procedure for T1 victims is only possible if the number of T1 victims is limited (i.e. less than five). Also according to the experts, with a larger number of T1 victims wet decontamination on the disaster site could be considered, but the survival rate will be low.

The **decontamination of T2 and T3 victims** should always start with dry decontamination. As in the UK an emergency disrobe and dry decontamination step prior to the arrival of specialist resources could maximise the use of time during the earliest phases of an incident. We know from the literature that the effectiveness of disrobe and decontamination decreases rapidly with time.[48] The efficacy of dry decontamination is substantially reduced if the contaminant is a solid, such as a powder.[64] Depending on the decision taken by the doctor in charge on the site of the incident (medical director DIR-MED) in concertation with the medical expert-advisor on dangerous substances, dry decontamination can be followed by wet decontamination on the disaster site, before the victim is transported to a hospital (if hospital care is needed). After wet decontamination, victims can be transported towards a type I or type II CBRNe hospital, depending on the complexity of the injuries and whether medical CBRNe expertise is needed for the treatment. The decision regarding the type of hospital should be taken by the Dir-Med in concertation with the medical expert-advisor on dangerous substances (i.e. medical AGS)

In addition to this decontamination strategy the following attention points need to be taken into account.

- It is essential to keep the mobile victims at the transition point between the hot and warm zone (i.e. avoid self-evacuation) and **initiate disrobe and dry decontamination with minimal assistance while waiting for specialised resources**. Emergency clothing should be available, as well as means to give victims a minimum of privacy.
- The experts consulted during the workshops emphasised the importance of **operational freedom**, meaning that the DIR-MEDtogether with the medical expert-advisor on dangerous substances (i.e. medical AGS) must be enabled to take decisions on a case by case basis.
- Even after wet decontamination, it is not 100% guaranteed that the victim is completely decontaminated. Therefore in the processes after decontamination (transport, treatment at hospital), the **possibility of residual contamination should always be taken into account**. The ambulance staff should wear protective clothing, and the receiving hospital should be informed about the nature of the incident, the hazardous product involved and the decontamination procedure carried out on site.

Wet decontamination of a large number of casualties requires a **mobile decontamination unit that is quickly on-site** (i.e. short response time) **and operational.** Wet mass decontamination is currently the task of the civil protection service. Regarding wet decontamination, the RD of 10 June 2014 stipulates that the civil security services are appointed to decontaminate the population (without mentioning a minimum number) and

[c] Partial decontamination means that only the body parts that are subject of medical treatment are decontaminated (see the manual of the FPS Public Heath for more details).

interveners if they are more than 20. Currently the fire brigade is only responsible for the wet decontamination of interveners if less than 20 persons are involved[65].

Although from a legal point of view wet mass decontamination is covered by civil security services, in practice – as arose from our expert consultation – there seem to be some difficulties.

- The civil security service is equipped with two mass decontamination unites, one with a capacity up to 20 persons, and one with a capacity up to 100. The activation time is respectively 30 to 60 minutes after arrival. Response time depends on travel distance and traffic. By consequence they encounter difficulties to cover the whole territory in a reasonable time span.
- Wet decontamination should be carried out with warm water because the risk of hypothermia does not outweigh the removal of the last 20% remaining after dry decontamination. Recommended temperatures vary between sources: in the Netherlands 32°C is mentioned in the decontamination protocol, while other sources report 35°C.[63, 66] The current mass decontamination units of the civil security services can provide heated water.[67]
- Civil security service has no medical, but only technical staff. This is troublesome if injured people need wet decontamination. Hence, support from other services will be needed, for example, the medical team(s) of the CBRNe MUG-SMUR(s) or ambulance /PIT/ MUG-SMUR if able to function in PPE and familiar with decontamination procedures.

By consequence it is unclear who is responsible for the decontamination of a few victims (n<20) or injured victims as the civil protection service has a long response time, is mostly equipped for mass decontamination, does only have technical staff available and the fire brigade is only responsible for decontaminating intervenors.

In Norway, the decontamination strategy with mass decontamination units was abandoned because it took 30 minutes to erect and the units arrived on scene only after about 90 minutes. Therefore it was decided to shift decontamination on scene to the responsibilities of the fire department and keep the system simple: cutting off clothes and hosing off the victims (i.e. Ladder Pipe system). The Norwegians calculated that the time lag before the start of life saving treatment could be reduced to three to six minutes after evacuation to the warm zone. As Norway has a dispersed population, decontamination methods need to be able to be carried out anywhere in the country and with basic means.[68]

From the literature, procedures used in the countries studied and expert consultation we learned that mass decontamination (both dry and wet) of injured victims (T2) on site is very complex, demanding, and requires medical expertise and knowledge about decontamination procedures (e.g. how to remove clothes).[59] For the decontamination of T3 victims and uninjured contaminated persons, knowledge about decontamination procedures, but no medical expertise is required. In Norway and the Netherlands the decontamination (both dry and wet) of non-injured people is done by the fire brigade, while the decontamination of injured victims is carried out by medically trained personnel. In the UK, uninjured and lightly injured victims have to disrobe and perform self-decontamination with minimal assistance.[62]

5.3 Preconditions to the organisation of prehospital emergency response to a CBRNe incident

5.3.1 A CBRNe plan needs to be integrated in the medical intervention plan

The aim of the medical intervention plan (MIP) is to define specific medical management procedures adapted to large-scale collective incidents in order to guarantee appropriate care for all victims. This way obstruction of the regular medical infrastructures and services by an (uncontrolled) influx of victims should be avoided and the continuation of daily emergency medical aid guaranteed. The MIP also includes the qualitative and quantitative criteria that are taken into consideration to evaluate the gravity of the situation and to determine the resources that need to be mobilised. Depending on the number of victims (quantitative criteria) the MIP, the extended MIP or the MAXI MIP is activated.

Currently, the MIP does not include a specific section on the regulation and coordination of CBRNe victims although this type of injuries requires specific expertise, resources and precautions (e.g. protective clothing in case of CBRNe injuries). More specifically a CBRNe incident differs from another disaster in three ways: the importance of early identification of the hazardous substance [16], the triage and stabilisation of potentially contaminated victims, and the need for decontamination of contaminated victims as much as possible on-site. A CBRNe plan integrated in the MIP/PIM could be envisaged including guidelines to raise the qualitative and quantitative criteria that are needed in case C, B, RN or e are involved.

Comparable to what happens when the BABI (Belgian Association for Burn Injuries) plan[d] is activated, a CBRNe plan or section in the MIP could activate a rapid medical response with medical CBRNe expertise at the disaster site and/or in the hospitals providing first aid (comparable to a B-team in the BABI plan) and quickly put all CBRNe type I hospitals in a state of alert allowing them to increase their bed capacity if needed.

5.3.1.1 CBRNe team of medical expert-advisors on dangerous substances

Experts in CBRNe medicine working in type I CBRNe hospitals or working at other organizations (e.g. FHI, Anti-Poison Centre, Belgian Army) could also be organised in **a supra-hospital network of medical expert-advisors on dangerous substances who are 24/7 on call** (cf. BABI Burn teams).[69] These medical expert-advisors should be able to **provide advice to the DIR-MED** relative to the health effects of dangerous materials, treatment of victims, protection of the population and the organization of the medical prehospital chain. When an incident occurs the medical expert-advisors in dangerous substances can operate remotely (e.g. by means of telemedicine). However for large scale incidents (e.g. maxi-MIP) they should be able to be on site (e.g. in the operational command post CP-OPs – PC-OPs) to provide advice to the DIR-MED or at type II CBRNe hospitals. By consequence, a CBRNe-team of medical expert-advisors could be considered.

The function of medical expert-advisor on dangerous substances is comparable to the hazardous substances health advisor (*gezondheidskundig adviseur gevaarlijke stoffen GAGS*) in the Netherlands. The GAGS advise on the health risks for the population and on measures to be taken to prevent or limit health damage as much as possible. They play an essential role in the determination of the adequate decontamination procedure on the disaster site. They closely collaborate with the hazardous substances advisors (*adviseur gevaarlijke stoffen (AGS) – conseiller en substances dangereuses CSD*) affiliated to the fire department.

[d] Established by the non-profit organisation Belgian Association for Burn Injuries, the BABI plan is the national plan for the coordination and regulation of beds for patients with severe burn injuries. It complements the medical aid chain of the medical intervention plan (MIP), but is not integrated in it. The BABI plan regulates the principles of mutual aid between burn centres in the event of accidents involving a large number of burn victims. In short it quickly alerts all burn centres so that they can increase their bed capacity, they activate a rapid medical response of specialists in burn injuries at the disaster site and/or in the hospitals providing first aid (B-team), they organise the distribution of secondary transport of burn patients, and they establish contacts with neighbouring countries in case international assistance is needed.

5.3.1.2 Dispatching and activation of the CBRNe plan

The same authorities could be responsible for the activation of a CBRNe plan (i.e. Dispatching 112, MUG-SMUR, MUG-SMUR doctor at the disaster site, DIR-MED, FHI and burn centre/CBRNe type I hospital closest to the disaster site). The dispatching for CBRNe could be part of the current Dispatching 112.

5.3.1.3 Tracking of bed, reception and surge capacity

In contrast to burn injuries, there are no beds specifically designated for CBRNe patients, with the exception for the high infectious units, the services specialised in infectious diseases (L-beds) and the treatment of the bacillosis/tuberculosis (B-beds) for B-patients. By consequence, the daily tracking of the bed capacity could be useful for B-patients. After thorough decontamination C and e patients become regular trauma or burn patients. Decontamination RN follows the same rationale, but decontamination RN should never delay or impede stabilization of any patient. The decontamination process and the following care in RN contaminated patients is more complex, and is influenced by type of contamination (external or internal), exposed radiation dose and type of radiation.

When the CBRNe plan is activated, every CBRNe type I hospital could determine its reception and surge capacity and inform the CBRNe dispatching centre (i.e. Dispatching 112 or BABI dispatching centre). Based on the information received, the CBRNe dispatching centre organises the distribution of patients among hospitals (i.e. CBRNe type I hospitals). At the demand of the authorities who can activate the CBRNe plan, the CBRNe dispatching centre engages one or several teams similar to the current B-teams to advise the DIR-MED at the disaster site and/or staff in the hospitals providing first aid (i.e. CBRNe type II hospitals). Finally, in collaboration with the Federal Health Inspector (FHI), the CBRNe dispatching centre could take care of the daily follow-up of the number of hospital admissions, number of patients in critical condition, and deceased patients. Information on bed, reception and surge capacity should be shared through information systems such as Paragon.

5.3.2 Health workforce capacities should be enhanced

5.3.2.1 Training, expertise and awareness call-takers of the dispatching 112

CBRNe incidents occur too little for care providers to develop a sensitivity for CBRNe. Hence, trainings and drills are needed to keep skills up to date and create awareness. This not only accounts for emergency responders, but also for people at junctions or information hubs in the system, for example call-takers of the emergency dispatching 112 or receptionists at ED of hospitals. According to the consulted experts, recognition of CBRNe incidents by 112 call-takers is crucial as it allows for early warning of emergency responders and hospitals, and activation of the CBRNe section of the MIP.

Early identification of a CBRNe incident, including identification of the agent and the risks it brings about, is a precondition for the emergency dispatching 112 to send out the adequate equipment and the right people. The emergency dispatching 112 needs accurate information to start up the appropriate response.

In addition, the call-takers should be able to recognize patterns when several calls concern people with the same symptoms. Moreover, they should be aware and be able to recognize the possible presence of hazardous materials. This way the first responders (first on site) can wear appropriate PPE before entering the scene. As stated in literature during the sarin attack in Tokyo more than 50% of victims were first responders[30]. Similarly, they should be able to interpret the information they get from emergency responders on site and pass it on in a correct way. Currently, the 112 calls are handled by non-clinical staff based on a standardized inquiry and standardized process book.[70]

During the interviews and work meetings, several experts said that 112 call-takers would benefit from a more advanced training and regular updates to fulfill their tasks appropriately. Now call takers are recruited a level C (upper secondary education). Before entering the job, they are trained in six months' time to carry out difficult tasks such as regulation and crisis communication.

For comparison, in the Netherlands, the team leaders CBRN-explosives and safety act as risk analysts at the Dutch emergency central (*meldkamer MKA*). They assess whether the threat is such that fire and ambulance services should be called in. The emergency central alerts hospital(s), noting the possible arrival of contaminated victim(s) and the possible arrival of contaminated T3 self-referrals.[63] Operators at the emergency central need crisis-communication skills, medical knowledge and logistical understanding. Operators are nurses who succeeded in an additional training on the job called "*verpleegkundig centralist meldkamer ambulancezorg VCMA*". The training lasts on average nine months, during which one day/week is foreseen for training.[71]

In Norway, the medical dispatch system is nationally organized and handles all medical emergency calls whether routed directly to one of the 19 large hospital-based dispatch centres or received initially by one of the many smaller community-based medical centres. All calls using the national medical emergency telephone number 1-1-3 are automatically routed to the nearest hospital-based dispatch centre. The medical dispatch centres are staffed by registered nurses and paramedics who take calls from the general public, healthcare facilities and other cooperating partners such as the Police and the Fire Department. The operators are required by Norwegian law to be licensed healthcare workers, and undergo internal training at the medical dispatch centre after employment.[72]

5.3.2.2 Disaster drills and training

The NCCN regularly coordinates exercises for each national emergency plan e.g. at least one nuclear emergency plan exercise takes place every year. The latter are defined by the nuclear emergency plan for the Belgian territory. Limited nuclear disaster drills take place every year (e.g. tabletop or commando post drills) and every three years a drill on site is organized involving all actors included in the nuclear emergency plan. Other types of disaster drills are organized at the initiative of provinces. There is a large diversity between provinces and often these drills are organized on an ad hoc basis. The calendar of disaster drills is integrated in the ICMS platform, and will be siphoned in Paragon (the national safety portal). In most disaster drills only one discipline is involved. Multidisciplinary disaster drills are scarce, while we know from the interviews that communication between disciplines is often challenging, suggesting that multidisciplinary disaster drills are very useful in this regard. In addition, most drills are table-top exercises, not full-scale on-site simulations of real situations.[73] Also there is a lack of financial resources to buy equipment to practice and create conditions as close to reality as possible.

Scenario testing can be done at a number of levels ranging from desktop exercises through to widespread field exercises. The evidence suggests that while field exercises have a purpose, they do not necessarily achieve improvements in preparedness that justify their costs. They are valuable for promotion and public awareness but the individuals involved in those exercises are so unlikely to be the same individuals as are involved in operational responses that the training benefit is likely to be very limited. On the other hand, desk top exercises may help test the assumptions and develop the coordination expertise required to ensure optimal response. It may be that desk top exercises may be enhanced by modern gaming technology to provide more real world experiences.

In addition to specific emergency plan drills, there are also more general training initiatives such as the postgraduate training on disaster management. The course aims to comply with the clear demand for professional and multidisciplinary training to help personnel of emergency and security services to cope with large-scale incidents. There is also an inter-university and international course targeting at all postgraduate healthcare professionals involved in disaster management at the local, national and international level.[74, 75] Moreover, the International CBRNe Institute (ICI) is hosted in Belgium. It was established by a RD of 30 August 2013 as an independent International Non-Profit Organization.[76] The International CBRNe Institute aims to enhance CBRNe risk mitigation at the regional, national and international level engaging several activities such as developing and supporting academic and policy-related research, organizing conferences, seminars, and workshops, and contributing to professional development for responders (basic to command levels). Training and risk education is attribute to a specific task force within the International CBRNe Institute. For specific trainings, the International

CBRNe Institute collaborates with the Belgian government, hospitals and professional organizations.[76]

5.3.3 *There is a need for an inventory and stock of supplies (antidotes, PPE, medicines)*

Throughout our interviews we heard the need for a continuously updated inventory of supplies (e.g. antidotes, PPE, medication) and a rotating central stock of supplies to avoid that stocks expire and money wasted. This need was also already mentioned in the 2019 report of the Superior Health Council on pharmaceuticals in case of a CBRNe incident.[16] In addition, it would give an overview of what kind of supplies are available and where they can be found.

5.3.3.1 *Antidotes and medicines*

Among all supplies, we zoom in on antidotes, because they are the most demanding example of all types of medical supplies. They are demanding in terms of stocking and transport conditions, they are expensive and expire over time. A reflection about these products uncovers problems that also account for other types of supplies (e.g. PPE).

Interviewees referred to the train accident in Wetteren (Belgium, 2013) to illustrate that antidotes are available at different facilities (such as chemical companies, civil security service, hospitals, Anti-Poison Centre, collaboration with neighbouring countries, defence, pharmacies and pharmaceutical companies) but that there is no clear procedure to access these antidotes.

It is unknown which products are available where. The national strategic stock is currently not transparent, nor directly accessible for healthcare providers. In addition, the Belgian Army used to be able to produce specific antidotes. Now they mainly rely on agreements with other countries. This makes the Belgian healthcare system less resilient, as we depend upon cross-border agreements. These agreements are not regulated at European level.

Antidotes are mainly stocked at the Belgian Anti-poison centre, individual hospitals, SEVESO companies and the army. There are also antidotes available at pharmacies, zoos and at the civil protection service (i.e. Iodine). Following the interviews, SEVESO companies are obliged by law to foresee antidotes for their employees. Some hospitals stock the antidotes for the companies with which they have agreements. The 'codex welzijn op het werk'/'code du bien-être au travail', stipulates the employer shall provide the necessary, such as emergency showers, and neutralizing agents to minimize the effects of unwanted releases of chemical agents as far as possible. Currently there are no guidelines, nor consensus in Belgium regarding how and where antidotes should be stocked. It is unclear who should take the initiative to build consensus. Interviewees suggested to create a continuously updated inventory of antidotes, e.g. at an online platform. In addition, they launched the idea of having a number of decentralized stocks for example in CBRNe type I hospitals. However, at the same time they raised the question who should manage them and keep them up to date.

The Belgian Anti-Poison Center organizes a yearly questionnaire for all hospitals to list the antidotes they have in stock. This way they try to get an overview which enables them to refer a demand of a hospital to another hospital. In terms of distance this can be more efficient than delivering the antidote themselves. However, only about 50% of the hospitals respond to the questionnaire, as the questionnaire is not obligatory for hospitals to fill out. The anti-poison centre has a small stock of anti-dotes that can be used occasionally for accidental acute intoxications. They receive about one demand each month (e.g. total n=16 for 2020). Hospitals pay the purchase price, as making profit out of selling antidotes would be in contradiction with the mission of the anti-poison centre.

Antidotes are expensive and reimbursement depends on the type of antidote, as well as the indication for which it is used. The question was raised whether policy makers should free a budget and experts should be appointed to determine which antidotes should be permanently available in a national stock. Also, antidotes expire, so stocks need to be kept up to date. To avoid expensive antidotes go to waste, the option of a rotating stock and exchanging antidotes among European countries was suggested. Also the

Superior Health Council encouraged in their 2019 report[16] on pharmaceuticals relevant in case of CBRNe incidents, European and international cooperation regarding the availability and maintenance of pharmaceutical stocks and cross-border incidents. In order to strengthen the European Health Union with better EU preparedness and response to serious cross-border health threats, by enabling rapid availability, access and distribution of needed countermeasures the European Health Emergency Preparedness and Response Authority (HERA) was created.[77] The European Commission realized that emergency situations require large-scale planning for preparedness and response in order for countries to be able to cope with unforeseen challenges. They recently funded many projects to work on different aspects of crisis management, many with a focus on managing pandemics. Looking at other countries, a national stockpile is one of the main pillars in the preparedness of the US.

Stockpile breaks in hospitals are another problem regarding antidotes. Hospital pharmacies are under high pressure to rationalize their stocks. They question the need for products that are expensive but not often used. For some antidotes only one component is available, which makes them useless.This agrees with the findings of Moore et al. (2015)[78], who conclude that medical stockpiles outside of the hospital environment, even when at strategic locations, can leave a hospital vulnerable to shortages in acute surge situations. However, maintaining reserve capacity at hospitals costs and could complicate distribution.[79] In the literature, the question of stockpiling or distribution is concluded by looking at local needs, hazards and risk assessments to determine the most appropriate strategy.[44]

Recently the FPS Public Health took initiative for the creation of a national stockpile. Housing and maintaining a national stockpile is very costly. In the international literature and in the key person interviews a dynamic rotating national stockpile was suggested (see section 4.3.1). Periodic reviews and dynamic use of stockpiles are necessary to ensure the effective use of the stored equipment and other items before their expire.

5.3.3.2 PPE

Hospitals mainly purchase their own PPE to protect their staff (see e.g. https://werk.belgie.be/nl/themas/welzijn-op-het-werk/collectieve-bescherming-en-individuele-uitrusting). Hospitals may have sufficient PPE available, as well as PPE availability in national stock, but knowledge is needed about the correct use of the equipment, and skills to work in PPE need training. Working in PPE is very labour-intensive, hence teams should rotate every hour.

In the light of the organization of hospital and prehospital response to CBRNe emergencies as described above (see chapter 4 and 5), PPE is needed in level I as well as level II hospitals. However, in level II hospitals, PPE is needed to protect staff, perform dry decontamination, and initiate wet decontamination for victims with less complex injuries. Level I hospitals will receive victims with more complex care needs, and other referred patients, which widens the timeframe in which they need to operate in PPE. Moreover, more teams of trained staff should be available to conduct decontamination and therefore the capacity of PPE will be higher. In the light of a rotating stock, level I hospitals could also stock a limited amount of PPE to scale up the capacity at level II hospitals if needed.

5.3.4 Healthcare system information systems need to be efficient

5.3.4.1 Communication and information transfer

Communication is strongly associated with safety. If something goes wrong at the moment of an incident, it can often be traced back to communication problems. The importance of communication cannot be overestimated, especially in stressful, often chaotic crisis situations. Adequate communication protocols (process) and technology (devices) were emphasized by the experts consulted, but were also stressed in the recommendations of the 2019 report of the Superior Health council.[16]

Evaluation and update of the material for communication

Concerning devices in Belgium, the experts consulted mentioned that the current radio communication is not high-performing. The wearables (earbuds) are outdated, people are difficult to understand and radio's must always be kept charged. The problems with radio communication brought about a parallel mobile communication (e.g. by mean of Whatsapp messages) between emergency responders, however the mobile communication systems are vulnerable to the acute increase in demand when a mass event takes place, which means the transmission of information can be severely hampered. With the terrorist attacks in Brussels, internet connection was down, and communication was hampered. Breakdown of communication networks (often the target of cyber attacks during terrorism attacks) should be avoided, or can be anticipated by the creation of off-line applications.[27] The Belgian communication network for all emergency and security services to secure information transfer used, is ASTRID (All-round Semi-cellular Trunking Radio communication system with Integrated Dispatching).[80] ASTRID has a status of limited company under public law and was founded in 1998 on the initiative of the federal and local authorities. It offers four essential basic services: radio communication, paging, Blue Light Mobile and dispatching solutions. ASTRID currently provides critical communications for all police zones, all fire brigades and most rescue and security services.

Concerning the communication process and protocols, communication entails different paths: between local and central governements, from authorities towards the public, within the different services of a hospital, between hospitals, between first responders at different levels, monodisciplinary and multidisciplinary, which indicates the complexity of an adequate crisis communication. Especially multidisciplinary communication is challenging. Ensuring information exchange and meaning in emergency situations, including real-time exchange of information, advice and opinions between leaders, experts, and the public is a prerequisite. For that, procedures should be outlined and tested.

Ensuring early recognition of the agent and rapid communication

The suspicion and subsequent confirmation of a chemical agent ('recognition') needs to be rapidly communicated to all first responders as well as relevant hospitals. The lines of communication between different disciplines need to be effective to ensure the correct information is sent to those who require it.

- Surveillance systems, at different levels, should be used to monitor and warn for plausible disasters. They facilitate the early awareness of plausible disasters and can effectively alert officials to the presence of potential events. Unlike surveillance in other departments, hospitals can detect potential biological diseases earlier, establish a virus transmission model, using artificial intelligence, and improve biosafety defence planning by analysing the association between in-patient conditions over a period of time. In this way, precautions can be taken in advance to reduce the surge in hospitals. Also identifying the type of bioterrorism agent (e.g. by the laboratory) plays an important role in improving the response of hospitals to bioterrorism events.[30]
- An early warning system can facilitate communication between pre-hospital setting and hospitals to receive information from the scene before arrival of the first victims.
- Specific structures can also be developed to centralize communication and coordination in order to rapidly respond such as an incident command system (ICS), at different levels. It should focus on responding in-time such as by endorsing timely evacuation, continuous assessment of the needs, the logistics and supplies, human resources, etc.[21, 27]
- Communication with the public is necessary to inform them in a timely manner, avoiding people rushing to healthcare professionals and organizations to reduce surge pressure by reducing fear and anxiety among the public.[30] In Belgium, the Be-Alert system is developed to inform the public (see section 5.3.7) but also D5 teams play a role in public communication.

- The Crisis Support Team (CST)[81] can assist the municipal and provincial coordination committee as well as the operational command post in crisis management. The CST can be called upon as soon as the operational coordination is in place. The CST is mainly composed of volunteer emergency planning coordinators with significant experience in emergency planning and crisis management, available across the whole Belgian territory. The tasks of the members of the CST are mainly to structure and optimise the exchange of information.

Early recognition is facilitated with the access to information systems such as databases

In case of a CBRNe event, healthcare providers should be able to consult specific databases as there are many different substances. Gathering information on the material, form, route, and duration of exposure to evaluate the chemical toxity and apply the necessary countermeasures is key. In Belgium, the BIG database is a relevant database on that topic[e]. As it is initiated by the fire department, it is not freely accessible for all healthcare providers. Also the medical-advisors and FHI, described in our scenerios, should be able to access relevant databases. The databases should have features such as having a simple, easy-to-use and accessible system, using everyday language that is easy to understand and act upon, providing accurate and reliable information of high quality (preferably evidence based), providing integrated multi-device platforms available for PC, laptop, mobile data terminals, command and control systems, tablets, and mobile phones. Other examples of relevant databases are the medical management guidelines for acute chemical exposures from the Agency for Toxic Substances and Disease Registry (ATSDR[f]), the Chemical Hazardous Emergency Medical Management (CHEMM – USA), or the European Chemicals Agency (ECHA) website, which the unique source of information for the chemicals manufactured and imported in Europe. The latter provides hazardous properties of the chemicals, classification and labelling, and information on the way for using them safely. Material Safety Data Sheets (MSDS) can play a role in identifying the chemicals.[27]

5.3.4.2 ICMS-Paragon

The Incident and Crisis Management System (ICMS) is a national security portal for Belgian services involved in emergency planning and crisis management of the Federal Public Service Internal Affairs.[82] From January 2024, ICMS will be replaced by Paragon.[83] The developers of Paragon aim to describe the complete disaster management cycle in the program, in order to help stakeholders of the National Crisis Center (NCCN) and organisations involved in crisis management. It is a web-based program, secured, multilingual and scalable. In the initial phase however, focus will be put on the preparedness and response phase. Paragon aims to enhance involvement and to facilitate communication between all operational services (e.g. authorities (federal, communities, provincial, municipalities), disciplines (D1-D5), industry, harbour, airports, military, police, fire department, etc.) involved in crisis management.

Paragon is currently still under development, and will be developed in different phases. The developers aim to include among others the available bed capacity of hospitals, the national emergency plans, risk analysis (e.g. maps with risk localisation, pipelines, climatologic circumstances), logbook, etc. In the future, extra functionalities will be integrated such as training modules, a register of chemical agents, water levels, etc.

Paragon is financed by European funding together with funding of SEVESO (chemical) and nuclear sector.[84]

[e] See more on BIG here: https://www.big.be/

[f] See more on ATSDR here: http://www.atsdr.cdc.gov/mhmi.html

5.3.4.3 *Post-incident follow-up*

Registration and quantification of CBRNe victims

Next to means of communication, also the availability of information is essential. Health information technology supports patient care in clinical orders, documentation and communication of clinical care, diagnostic and other test results, and patient tracking.[24]

Tracking all potentially exposed persons (not just those with clinical symptoms) from the incident site to different treatment centres or other locations is very challenging, especially for those that self-evacuate.[44] Studies on past disasters found that paper medical records are rarely accompanying the victims during disasters. Moreover, there is a limited use of electronic medical records. Also note that the latter systems can be at increased risk for cyber-attacks during ongoing disasters. To be able to use medical patient records, the infrastructure information and communication lifeline should be safeguarded.

Tracking of patients once registered at the hospital is routine. However, in Belgium CBRNe victims can be registered under a multitude of administrative codes (e.g.ICD-10, APR-DRG) in hospital data. There are plenty of possible identifiers, such as administered medication, type of hospital bed, ICD-10 code, etc. Therefore estimating the number of hospitalized CBRNe victims is not straightforward, nor self-evident, as there is not one specific code for CBRNe. Hence the quantification of the number of CBRNe victims is challenging. In Belgium, victims of collective emergencies are registered by means of the Belgian Incident Tracking System (BITS). Note that BITS is not coupled to the hospital medical record of victims. Moreover, single cases who had a small scale CBRNe accident are not counted in BITS, and should be identifiable by means of hospital data.

Post-incident biomonitoring

The WHO has been recommending health outcome assessment during or immediately after an incident as part of disaster management in its 'Manual for the Public Health Management of Chemical Incidents'.[85] Human biological monitoring "*allows to determine the internal dose of a chemical absorbed by an individual after acute or chronic exposure*" (p. 306).[86] It is a well-established tool in occupational and environmental medicine, but in Belgium it remains underused in the context of CBRNe.[86] In the aftermath of the 2013 train accident in Wetteren (Belgium), a biomonitoring study was set up. The Belgian Minister of Social Affairs and Public Health advised to perform a biomonitoring study to assess the exposure to acetonitrile in the populations with highest suspected exposure, i.e., the residents of Wetteren and the emergency responders.[87] Not every incident calls for a detailed exposure assessment, but at the same time the window of opportunity for a detailed exposure assessment is limited, which puts pressure on the decision when to act.

With the aim of safeguarding public health, the Flemish Government initiated the development of a decision support system. This system must help public health officials in identifying the appropriate actions in case of chemical release incidents. Biomonitoring is one of the instruments amongst others such as eco-surveillance and food surveillance. Abroad the development of similar procedures have preceded the Flemish decision support system, e.g. the German "public interest–legal liability approach for the application of chemical incident[88] and the Dutch "pre-defined transparent procedure for early decision-making following chemical incidents".[89]

Regarding the health risks of first responders (e.g. fire fighters, medical personnel), biomonitoring could be part of occupational medicine. However, from what the interviewees reported, biomonitoring is not systematically considered in case of a CBRNe incident, neither for citizens, nor for first responders. Nevertheless the immediate collection of samples after the accidental release of a chemical would allow the generation of exposure data on an individual and aggregated level to assess the public health risks, initiate appropriate medical treatment[89], assure appropriate risk communication and respond to legal liability cases.[86]

Post-incident evaluation CBRNe incidents and disaster drills

In addition to a register of supplies, it would be useful to have a national registration of CBRNe incidents. As far as we know such a register does not exist, and the evaluation of how incidents were managed is not systematically done, but is left to the individual initiative of the federal health inspectors.[35] In addition, lessons learned are not consolidated, nor shared with other emergency responders. The few accidents that happen should be used as a learning opportunity for all actors involved and as a leverage to improve the response (e.g. protocols, communication means). Systematic and system-wide evaluation after an incident is absent, and lessons learned, if any, are not systematically used as a leverage for change. Lessons learned are often not implemented in revised versions of preparedness and response plans and therefore do not contribute to improving the overall approach to crisis management.[16] However, the development of BITS can be considered an example of how lessons learned can lead to adapted processes to improve their response in case of a future incident. BITS has been developed since 2019 in response to one of the recommendations from the Parliamentary commission of inquiry into the 2016 terrorist attacks.

Also at hospital level, post-incident evaluation should lead to organizational learning. Mitigation happens when experiences are transformed into beneficial changes in the organization's collective knowledge, cognition, and actions by adopting an active learning approach.[26] Most hospitals around the globe return to their routine activities once the 'response phase' is ended, and therefore missing the knowledge that might be generated by reflective processes.[26] During crisis situations, teams and staff members continuously create profound innovative ideas and practical problem solving strategies in dealing with and coping with challenges (e.g. patient surge and lack of PPE, treatment protocols, or caring plans). It is expected that the emergency coordination cell at the hospital evaluates and integrates these lessons learned in the hospital emergency plans, which are dynamic and evolving.

An example of procedures for post-incident evaluation is seen in SEVESO companies, where there are obligations to evaluate the incidents, alongside reporting at various levels, including at European levels. The division Control of Chemical Risks of the FPS Labour and Employment edits information fiches where lessons learned from previous incidents are documented.

5.3.5 *There is a need for the financing of emergency planning and preparedness*

Lack of budget for emergency planning and preparedness

Emergency planning is an investment in what is unlikely to happen. Throughout our interviews a lack of budget was very often mentioned. Structural financing of emergency planning seems to be insufficient, or at least not in proportion to the services expected. Interviewees talked about implicit expectations, meaning that they are asked to provide a service, without associated financial resources being in place. Throughout our interview round it was clear that hospitals prepare for emergencies and provide their services, mostly by means of own resources (e.g. PPE, decontamination facilities, antidotes). Financing seems mostly reactive, or driven by the occurrence of incidents (e.g. after the terrorist attack in Maelbeek and Zaventem, the focus was on massive bleeding and damage control, after the Ebola outbreak, EPI shuttles were purchased).

Lack of structural hospital financing for CBRNe preparedness

There is no structural CBRNe financing for hospitals. Each hospital is obliged to have a hospital emergency plan, but interviewees pointed out that no additional means were attributed to it. The function of hospital emergency plan coordinator has been formalized in 2019 (e.g. [42, 90]), but without additional financial means. In addition, it does not matter whether the person appointed coordinator spends 10% or 100% of his time to this function. It is up to the hospital to decide in function of its size.

Being prepared is not financially attractive as it is an investment in what is unlikely to happen. Hence the return on investment (PPE, training, etc.) is perceived as low. Therefore, it is difficult to find a balance between costs

and benefits. For example, some hospitals built a stock of protective clothing at their own initiative and cost, but this is not feasible for all.

As funding often goes hand-in-hand with rules and regulations, the absence of legal guidelines for hospitals and regulatory requirements for their implementation (regulation and standardization), may hinder attribution of resources.[17] The availability of emergency or flexible funding to ensure swift resource mobilization, logistics and supply management is a necessary prerequisite for optimal hospital resilience. The lack of financial resources, limited autonomy at the facility-level, and disrupted supply chains were frequently mentioned barriers to COVID-19 response and, ultimately, hospitals' timely resilience. Funding plays a decisive role and directly affects the capacity of medical services (e.g. training, maintaining essential equipment, staffing, capacity building) and the resilience of hospitals.[26] and the healthcare system within a country.[17, 22, 30]

The budget for hospital infrastructure

Flanders created a new hospital infrastructure funding model consisting of two financing streams: the conservation lump sum and the strategic lump sum.[91] The conservation lump sum is intended to allow existing infrastructure (real and movable) to remain in operation. The strategic lump sum is intended to cover the costs associated with: the complete new construction of hospitals, the expansion of existing capacity, reconditioning works, the initial movable investments (medical and non-medical investments) associated with a new construction, expansion or reconditioning of a hospital. However, according the hospital umbrella organization (ZorgNet Icuro), the hospitals in Flanders have been structurally underfunded for infrastructure works since the State Reform in 2014.[92] It has been the intention of the new funding plan to link the strategic lump sum to the approval of a hospital network's healthcare strategic plan. To this end, the Flemish government called for a new procedure. Only since 1 April 2022 can hospitals submit their healthcare strategic plan for assessment under the new method. All hospitals do receive the conservation lump sum since 2017, but the total amount is not enough to structurally cover the real maintenance costs of maintaining hospital infrastructure (e.g. decontamination units, separate access ED). Regarding Wallonia and the French Community, they *"have devised a system based on individualized rights. Hospitals charge hospitalized patients an amount, known as the "accommodation price", charged per day of hospitalisation. This amount is paid by the insurers via the third-party payment system28. Theoretically, the "accommodation price" covers the costs associated with the use and development of the hospital infrastructure, as well as the renewal of the associated equipment (material and equipment).* (Information retrieved and translated from Henrard & Husden, 2021[93]). To date, no decision has been taken for Brussels[93].

The CBRNe expertise centre

The CBRNe expertise centre was founded in 2018 as part of the national safety strategy. The centre resides under the department of Emergency Planning of the National Crisis Center (NCCN) and is currently staffed with 7 FTE. Its mission is to reduce fragmentation in the field of CBRNe, facilitate integration, support initiatives of other actors in the field and coordinate own initiatives. They are active in the field of CBRNe safety, the operationalisation of emergency plans, crisis management, international collaboration and research and development (i.e. partner in about 70 international projects). The centre includes experts who are, whether or not, detached from the Federal Police, the Directorate General for Civil Security, the Federal Agency for Nuclear Control and Sciensano. They are awaiting a secondee from the FPS Public Health and the Ministry of Defence.

The role and tasks of the CBRNe expertise centre are broad in scope, while its manpower is rather limited.

Use of the SEVESO fund

The European Seveso directive[94] was drawn up to prevent major accidents involving dangerous substances and to limit the consequences of such accidents for people and the environment.[95] The Seveso directive was translated into the Belgian Law with the collaboration decree of 16 February 2016.[96]

There are two funds (sourced by annual payments of upper-tier chemical companies operators):

- The fund for the prevention of major accidents, provided for in the budget of the FPS Employment, Labour and Social Dialogue.
- The fund for risks arising from major accidents, managed by the NCCN. This fund pays for:
    - Costs of the external emergency planning for the upper-tier companies e.g. for drawing up external emergency plans and organising exercises.
    - Setting up information campaings (public preparedness).
    - Purchase and maintenance of specific intervention equipment.
    - Specific projects or purchases relating to the management of the major accident hazard.

The amount of the annual fee depends on the dangerous substances present in the chemical company.

5.3.6 Ethical issues require proper attention

During CBRNe emergencies prioritization in triage protocols changes from patient-centered to population-centered. Needs exceeding the available resources is inherent to the definition of a disaster. Hence, the emergency responders may have to prioritize medical interventions for those with the greatest survival chance.[44] This prioritization implies ethical considerations as the standards of care are reduced to provide aid to as many victims as possible. It is important to have pre-incident discussions about the triage and treatment protocols and develop a shared vision (and responsibility) about the decisions emergency responders have to take during an incident.

From the literature we also know that under-preparation of stuff capacity, just-in-time scheduled procurement supply chain models and stock rupture amplify the insufficient stock of items.[21] For example ethical issues arise if there are insufficient mechanical ventilators for the victims with respiratory failure. Healthcare providers must then select which victims receives a mechanical ventilator and which not. For healthcare professionals, this is particularly stressful. Therefore procedures should be outlined in the SOP for capacity. In the same, SOP strategies to ensure staff involvement could be outlined. The risk perception and motivation of staff and management also impacts preparedness for disasters.[17, 22] Strong internal communication, leadership, and clear SOP can increase staff's commitment.[24] Hospitals can improve staff's motivation by offering incentives such as financial extra's, access to PPE (and training), access to vaccines or anti-effective therapy, child-care arrangements, volunteer networks, adequate training, information and awareness on SOP, temporary housing, and protection from disaster-related legal sanctions.

A previous KCE report (2020)[97] on the management of hospital surge capacity in the first COVID-19 wave, recommended to formulate an advice that supports healthcare providers in making ethically sound choices during a crisis situation when the demand for care exceeds the supply of care. Also the handling of the deceased persons may be subject of ethical discussions.

5.3.7 Public preparedness needs to be increased

CBRNe threats have a catastrophic potential, which is frightening for the public. However, there are basic actions the public can undertake, which can reduce or prevent harm during such incidents. In addition, speed of action is important in CBRNe emergencies. The speed of acting can be enhanced by providing pre-incident public information about how to undertake action, and hence reduce their own risk. Also pre-incident information enables people to identify with emergency responders, thus making it easier for responders to communicate effectively with victims during an emergency. Moreover, the actions that people may be asked to take to reduce their risk during an emergency (e.g. disrobing, undergoing decontamination) might be embarrassing or uncomfortable. Providing pre-incident information on these actions and their effectiveness, may increase people's willingness to take these actions.[98] Finally, the risk of self-evacuations might be reduced by providing information on the do's and don'ts in case of a CBRNe incident (e.g. via BE-Alert). For example, a symbol indicating a gathering point for potentially contaminated people, may be promoted and communicated to the public to familiarise them with it. In a

recent systematic review the authors[98] concluded that providing pre-incident information generally results in an improvement in preparedness knowledge, behaviour, and/or intentions, compared to not providing any information. The findings showed that it is essential to provide information about the protective actions the public can take. This enhances the speed with which actions can be taken. In addition, information about why these actions are necessary as well as the efficacy of protective actions are key pieces of information.

Pre-incident information may be provided in different ways, for example online, through targeted local campaigns, and as part of the school curriculum. From the literature it is difficult to draw firm conclusions about the best method of providing information. However, research has shown that higher intensity interventions resulted in greater improvement in preparedness. A method with potential is video games, but only little research about effectivity has been reported.[98]. Another example is creating a national database of volunteers , similar to the USA, to increase awareness and involvement of the public.

6 FINAL REFLECTIONS AND LIMITATIONS

In **the current organization of emergency management in Belgium**, **hospitals play a main role**. In case of severe incidents (what is often the case in CBRNe events) the emergency departments with a specialized emergency care services, send out their MUG-SMUR teams. Also the 24 PIT teams (currently still financed by pilot projects) are located at these hospitals. Ambulance services are often located 'under roof'. These are the main services that will be provided by the 112 emergency call centre when a CBRNe event occurs. Primary care services and other public or community health services play a minor role in the current management of emergencies with high impact. However, in case a major disaster hits (healthcare services are also vulnerable to the hazards confronting the community more broadly) i.e. a disaster that disrupts the hospital and emergency management organization (e.g. damaged hospitals, evacuated hospitals, or hospitals shut down), primary care and community and public health services can play a significant role in the response and the recovery of the hospital and healthcare system. Note that one of the most significant adverse health impacts from disasters is the loss of access to routine healthcare, including emergency care. This may be because of disruptions to transportation and access or to lost functionality of the health system. Due to the scope of our research, focussing on the organization of hospitals, we obtained to provide elements which could enhance preparedness and resilience of hospitals. This excludes events that cause a complete disruption of emergency management organization. Focussing on these type of events, and the involvement of primary care and public health services, as well as collaboration within the hospital networks to consolidate expertise and/or stream patients, should be a topic of further investigation.

Due to their main role in emergency management, we took a **hospital centric approach**. Reflections were made regarding pre-hospital care too since hospitals send out their MUG-SMUR, PIT teams, and ambulances, and will receive the victims. The medical condition of the victims i.e. whether or not the victim is decontaminated and the medical care provided (medical condition related to severity of the injuries), will be determined by the services their teams (and the other disciplines engaged in emergency

management) provide in the field. The main approach to safeguard staff, regular patients and hospital resources, is **to decontaminate victims as much as possible in the field**, along with **the implementation of standard procedures to designate patients to hospitals** based on their medical needs and in-house expertise available at the designated hospital, taking into account the capacity. The latter can be compared to the BABI plan for patients with severe burns.

Decontaminate as much as possible victims in the field

Site decontamination is generally preferred as it avoids contamination of patient transport vehicles and health personnel and thus preserves healthcare capacity. It is best provided by those people with the capacity to train in its use. Familiarity from experience is very unusual because of the rarity of these events. As a general rule, a portable decontamination capability should be provided and strategically located to facilitate rapid response to potential sites.

There is a significant issue in terms of the site regulation and the use of hot, warm and cold zones. The application of this zoning is often difficult to achieve. Assumptions need to be clear. Traditional approaches to site management suggest that access into the hot zone is restricted to appropriately trained and equipped emergency personnel. Many jurisdictions determine that healthcare personnel should be restricted to the warm and cold zones, where they receive decontaminated patients. However, this approach is not universal and many healthcare workers agitate to be trained and equipped to enter the hot zone. This introduces an additional level of preparedness and training challenges. The practical reality is that it is almost impossible to provide patient care in high levels of PPE. That is why most jurisdictions have taken the approach that emergency services including fire services and military would evacuate patients from the hot Zone via decontamination. One should take into account that sometimes, the site may be difficult to define. The site may be widespread such as would result from a contaminated smoke plume, or there may be multiple sites. It is worth remembering that the purpose of the perpetrator of a terrorist attack is to create terror, therefore they will seek to maximise exposure and also to minimise the available information. Therefore, control of the site is always going to be challenging. Taking this into account, there is also a considerable risk for self-evacuations.

In Belgium there is one CBRNe MUG-SMUR, which is located at the Military Hospital Queen Astrid in Brussels. It's equipped with a mobile decontamination unit and antidotes, similar to PSM1 in France that can serve about 20 victims. Moreover, the military has the capacity to train regularly in its deployment and use. They have PPE on board and can operate in PPE. Moreover, the medical staff of the CBRNe MUG-SMUR is allowed to access the hot zone, which facilitates triage and the medical care (ALS) for critical patients. Take into account that financing more CBRNe MUG-SMURs and locating them at Type I CBRNe hospitals, requires also specific training and resources for these teams. The main decontamination capacity for victims (also in stretcher position) is however authorized to civil protection. The fire department is only authorized to decontaminate its staff. However, there are two major limitations to this task allocation: the response time of the civil protection's decontamination units is (too) long (due to their geographical location and the set up time of the decontamination facility) and they lack medical staff. They can neither access the hot zone. They are located in the field just before the advanced medical post. The fire department however, has medical trained staff and PPE available, they are regularly trained to operate in PPE and to execute minimal decontamination of their staff. They are allowed to access the hot zone, but are not authorized by current legislation to decontaminate victims. In some of the rescue zones, medical trained staff is trained to operate in PPE and to execute minimal decontamination. Moreover casualty extraction teams are trained to evacuate victims from the hot zone in a safe but faster way to increase their survival chances. Note that the capacity to decontaminate victims of CBRNe incidents in the field (i.e. mobile decontamination capacity) is limited in Belgium, in comparison with the other countries in our study. In order to strengthen decontamination in the field the following actions can be made:

- Investing in trained CBRNe MUG-SMUR teams located at Type I CBRNe hospitals could gather medical expertise, assist with triage, and enhance the speed of decontamination.
- Authorizing the fire department to provide minimal decontamination is in-line with operations in other countries and the literature. Especially for victims in need of urgent medical care and awaiting civil protection this could be a major advantage to safeguard healthcare providers, hospitals, and provide patient care. Moreover, it requires mainly an adjustment of the legislation as they are regularly trained and PPE is their 'standard equipment'. Authorizing the fire department to apply minimal decontamination to T1 victims before transferring them to a designated hospital may avoid contaminating vehicles and secondary contamination of healthcare personnel. Another advantage of authorizing the fire department to decontaminate victims, is that agreements can be made with Type 2 hospitals to manage the decontamination of self-evacuated victims.
- Victims that do not require immediate medical care for their injuries, and depending on the agent, may wait in the field for decontamination by civil protection. The fire department may assist D2 with initiating minimal decontamination.

Decontamination interferes with patient privacy, dignity and safety. Disrobing is an initial decontamination method. Privacy and dignity is an important consideration and so replacement clothing must be provided (e.g. offered by the SIT-FIT in the field, located at all hospitals). As suggested, a rudimental facility for wet decontamination (with hot and cold water) should be present outside the hospital buildings. It is rather low in cost but due to the rarity of such events most will never be used for their primary purpose. Clever and flexible design may improve familiarity and function. Watering systems for gardens or vehicle washing bays may permit such systems to be regularly used and thus reassure functionality. Clever design needs to take into consideration the privacy, dignity and safety of patients (e.g. wall constructions). Additionally, the disposal of contaminated clothing must ensure safety. Next to minimal decontamination procedures, also waste management operating procedures can be implemented in the hospital emergency plan. Also forensic requirements can be taken into consideration i.e. contaminated clothing can be placed in plastic sealed bags.

An important ethical consideration that requires more reflection is the risk of transporting contaminated T1 victims. Generally these victims need specialized medical care within one hour. There is no time to wait for the decontamination facility of the civil protection. Therefore we suggest to offer minimal decontamination to these patients by the fire department and/or CBRNe MUG-SMUR teams. The latter can also provide medical life-saving actions (ALS), before transporting these victims to Type I CBRNe hospitals. Since there is a significant risk for rest contamination (e.g. agent is present in the body due to wounds or trauma), contaminated T1 victims should be transported to Type I CBRNe hospitals, equipped with a fixed decontamination infrastructure for decontamination in stretcher position. These hospitals should have a separate entrance, in-house medical expertise (preferably in burns, major trauma, radionuclear services), and staff trained to operate in PPE. It should be taken into account that transport vehicles will be contaminated and healthcare providers can suffer secondary contamination. Therefore, the capacity to transport contaminated T1 patients is limited and brings in additional risks. In case severely wounded contaminated victims cannot be offered the needed medical care immediately, they should receive pain management and comfort therapy in the field. Again, this can only be provided by CBRNe expert physicians trained to operate in PPE such as the CBRNe MUG-SMUR teams. Especially in the field of disaster and emergency management healthcare providers want to save lives. However, contaminated patients pose a threat to healthcare workers and the broader community and so a rigorous policy position is often held that despite the risk to those individuals from delayed care the greater good is served by protecting others. This brings with the important issues about triage.

As indicated in this report, prehospital or site decontamination is best practice but cannot be guaranteed. Contaminated patients may self-evacuate (T2 and T3 victims), patients may not be aware they have been contaminated and there are unusual toxins that are not readily cleared by either dry or wet decontamination. Consider that victims who self-evacuate will plausibly go to the nearest hospital campus (whether or not equipped

with an emergency department). Therefore, we suggest to lockdown the facility for victims of the event and to foresee a place to gather these victims outside and to provide minimal decontamination. As every hospital (also a campus without ED) needs its own hospital emergency plan, cross checked with the community, province, regions and government, a standard operating procedure for decontamination and management of self-evacuated patients can be implemented. Hospitals' external decontamination capability is an important backstop, particularly for hospitals designated to be principal recipients of patients from CBRNe events.

The **lockdown of hospitals for CBRNe victims** is an important consideration. Hospitals generally are relatively flexible and accessible, but in the event of major incidents, efficiency depends upon organised streaming of patients in and out of the facility, including the decanting of patients out of the facility to make room for sudden acute demands. It is also critical to control entry by potential perpetrators, the media (to protect privacy) and families to prevent congestion and chaos. Finally, It is important to take into consideration the prospect of hospitals being evacuated because of contamination either aerosolised or biological, or direct attack.

Facilitate designating patients from the field to hospitals by implementing standard operating procedures

It is important to understand that currently the 112 operators often suggest to transfer to the closest hospital. In case of a large number of victims, it will be important to distribute the patients according to the expertise and services provided by the hospitals. For the reasons stated above, we suggest to transfer contaminated victims to Type 1 hospitals, as well as patients in need of specialized care (e.g. burns, major trauma, etc.). The 112 operators should be able to rely on accurate and on-time information on bed capacity. Moreover, their communication channels with the field should be safeguarded. A standard operating procedure for CBRNe events can be outlined in their manual, and should be aligned with the MIP. It is clear that there are many more aspects of pre-hospital emergency care and operations that we did not discuss in this report e.g. psychological assistance for healthcare professionals, victims and their relatives; the best location of an advance medical post; which type of PPE to use (we refer to guidelines of CDC and/or WHO); the role of other disciplines; forensics; response to mass casualty incidents with a whole of system approach; etc.

A significant challenge regarding CBRNe is in first instance **to be aware of the possibility** and in second instance **the ability to diagnose the agent quickly** which may determine the nature and means of decontamination, the risk to the general community and first responders, the use of specific antidotes and treatment. As outlined in our report, the aspect of awareness is especially important for 112 operators (which alert the first responders), and service desk operators at an ED as they can be confronted with self-presenters. Note that rapid identification of the substance is important but difficult not only technically but also in terms of the ability to deploy (and maintain) that capability. Thus all hazards approaches generally predominate.

A CBRNe all-hazards approach includes all types of events. In our scope, we eliminated events that cause a disruption of the hospital organization, as well as events that put hospitals under strain during a prolonged period. We considered manageability of the events based on the current emergency management, resources and expertise available. For example, for B-incidents we reasoned that some occur more regularly and are manageable by our current hospital system organization (e.g. legionella and salmonella). B-events as pandemics were excluded due to the fact that they are prolonged in time (mutations of the virus, speed of infection spread) which caused an extreme strain on healthcare resources globally. This would require another type of organisation in which the focus should be put on 'surge capacity'.[ref surge capacity] We believe that the organization suggested in this report might work for several events, also beyond our scope (e.g. legionella outbreak with 350 persons, terrorist attack in a densely populated city, single victims). Of course, at one moment, the capacity of a healthcare system might be overloaded, but this depends on more factors than the way hospitals are organized (e.g. availability of staff, capacity of stuff, space). This requires further investigation, as well as some suggestions made by the consulted experts and described in this report, such as:

- A decentralized rotating national stock – Currently it is unclear what is available and where it is located. It seems Belgium has an 'imbedded stock', which may be feasible for a small and dense country. Currently facilities (Seveso companies, hospitals, zoo,…) seems to invest in their own resources depending on their own needs. An overview starting from what is already available at these different organizations, should be made. Policy makers should subsequently decide which flaws to tackle. Questions concerning operational measures and procedures such as: Who should coordinate this stock? How many antidotes of what should be available? How to adjust our legal framework? etc. remain. Note that these questions are very complex to answer due to the diversity of events that can occur, with different impact and needs. In any case, transparency, accessibility, and a fast deployment are important elements for the efficient use of the stock and should be guaranteed for the relevant actors in emergency management. Clear leadership in process operations and strategic management is needed to align the resources available and investments already made. This strategic management approach to set out an efficient process of operations, could be further developed by FPS Public Health.
- Note that certain B patients cannot be 'decontaminated' when contamination is introduced into the body, either through aerosolised means or as consequence of infection. This requires another strategy and research actions.
- The issue of personal protective equipment needs a broader understanding. PPE is generally divided into four levels ranging from fully encapsulated breathing apparatus through to the general health protections common to healthcare infection control. It would be worth including this consideration in the determination of the levels of protection available. This issue is significant and interrelates with the site management of a contaminated site. For this we refer to guidelines of CDC and WHO.
- There is a need to consider the management of the **media and public communications**. Ordinarily this is the responsibility of senior officials within the healthcare system subject to broader public communication led by the government and emergency services.
- Some ethical considerations and societal implications were discussed in the report but require a more thorough approach and investigation.

Many concrete questions remain unanswered or are only vaguely explored. Since the level of preparedness and response is determined by many elements such as financing, availability of resources, the current organization of a healthcare system for a specific country, the political and environmental context of a country, etc. it is impossible to be exhaustive. The ideas expressed in this report are based on solid scientific methods to gather them, but could be topic of further investigation to understand the implications and their effectiveness more thoroughly e.g. ethical considerations, societal implications, costs and budgeting, boundaries of the healthcare system, etc. for topics that policy makers decide to tackle.

Concerning the geographical and demographical context of Belgium as a Member State of the European Union, we provided some European initiatives undertaken to enhance the preparedness of its Member States. There is a plea for a team Europe approach for this type of events. The European Union undertook some initiatives such as joint actions, trainings, drills, and endorsing countermeasures (e.g. stock piles). However, not all member states are always involved and there is no European legislation on how to manage these types of events as such. A role for the European Union could be to facilitate agreements (especially between neighbouring countries) and give directions in increasing their preparedness and response.

During the course of our research, many reflections were made how to **enable change**. Experts often state that more resources should be invested in trainings and drills. It is clear that the importance of training cannot be underestimated, however the capacity for training to be the solution to preparedness is somewhat limited. Requiring that all ED staff should be trained in decontaminating victims and to operate in higher level PPE is challenging considering the many competing demands for training on staff,

the shortages in staff, and also the rapid turnover of staff. More pragmatic nuanced approaches are required that incorporate training into recognition of the practical realities and the use of complementary procedures. Rather than to train all staff, a selection of staff who have leading roles in the EDs disaster response should be trained on the premise that some of these will be available at all times. Therefore, it is suggested to couple CBRNe MUG-SMUR (and their expert teams) to Type I CBRNe hospitals, and to train these teams thoroughly. Moreover the supra-hospital network of medical expert-advisors in dangerous substances who are 24/7 on call, can assist Type II CBRNe hospitals (cfr. BABI Burn teams) similar. This may then be complemented by the availability of simplified instructions that act as an aide memoire. Therefore we stress the integration of several standard operating procedures in the hospital emergency plans and to align them across hospitals and/or hospital networks and with the MIP.

Enforce the existing structures

To make things happen also requires a strategic approach under the guidance of relevant governance structures. In the field of CBRNe, at least 3 federal governments are involved in Belgium. One organization i.e. the **CBRNe expertise centre** was constructed in 2019 by Internal Affairs. However it aims to gather relevant experts from the involved governments. Few FTE are provided, and currently no expert from Public Health is detached to the CBRNe expertise centre. We suggest to endorse this centre and to involve experts from all 3 governments.

Funding is often a key enabler for change and to make things happen. However, there is always a significant debate around funding for CBRNe events. In the field of CBRNe emergency management the very tricky question of usefulness of money spend is particularly expressed i.e. How much money does society need to spend on events that will perhaps never happen?

Funding also relates to the expected level of preparedness. Many, particularly those involved in emergency and disaster management aspire to a level of 'perfect' preparation. It is important to recognise that preparation will never be perfect. It is difficult to have these conversations at a political or public media level, but the reality is that a level of preparation must be reasonable within the broader context of the economy, competing demands for resources and the practical realities. This is particularly relevant for healthcare where demands for resources for disaster preparedness is in competition with other healthcare challenges. It is e.g. not possible to put the healthcare system on hold for a day while undertaking a disaster exercise. People deprived of access to health care will suffer adverse health outcomes including death. This is an important consideration requiring more nuanced approaches to preparation and planning. One should be aware that every penny spent is essential when the problem strikes. But it is also very important to take into consideration a nations' political, societal and environmental context.

Central authorities may say that the preparedness of hospitals is part of the hospitals' service provision and thus belongs to the responsibilities of the service providers. Service providers may tend to say they are already overwhelmed with competing demands for funding. The compromise is usually met by central funding of community wide infrastructure and service provider funding of the care provision. Thus, central funding of capability development such as decontamination capability, stockpiles and additional training is required. Additionally, there is value in central funding of an ongoing policy analysis and development role, research and training capability.

It is relevant and important to understand that the **healthcare system especially in developed countries is under considerable pressure** on a daily basis from the combined effects of growing and aging populations, resource and workforce supply issues, the prevalence of chronic diseases, and the capacity of the healthcare system to do more for patients and thus raised community expectations of the capacity and quality of care provided. It is therefore difficult to layer onto that system under pressure additional or alternate responsibilities or accountabilities. The optimal solutions lie in "mainstreaming" these accountabilities and not simply adding on more. That

is integrating them into standard operating procedures wherever possible. Healthcare systems need to have flexible and scalable response arrangements which meet not only the daily challenges but also the exceptional challenges posed by disasters and major incidents.

7 CONCLUSION

We aimed at providing future directions to the organization of hospital and prehospital emergency response to a CBRNe incident in Belgium. The emphasis of the prehospital and hospital organization suggested for Belgium is mostly on C incidents with acute (after seconds to minutes) or slightly delayed (after minutes to hours) effects. The future directions are mainly conceptual and organizational, as operational and financial issues are beyond scope.

Since there is no scientific evidence about the best way to prepare for CBRNe emergencies, we used a mix of literature research and expert consultation to gather information on country-specific organizational models, challenges characteristic of the Belgian situation and how to overcome them. This strategy allowed us to combine what works abroad with the specificities of the context of the Belgian healthcare system in a conceptual proposition on the organization of hospital and prehospital emergency response to a CBRNe incident.

For the **hospital emergency response** we proposed to build on the already existing concentration of expertise in certain healthcare services and classify hospitals in two levels:

- Type I CBRNe hospitals which pool expertise and have the infrastructure to offer the initial and continuing care for severely injured victims with complex care needs relative to C, B and/or RN. Type I CBRNe hospitals are few in number and characterized by the highest level of specialization regarding CBRNe medicine.
- Type II CBRNe hospitals with or without heightened risk of self-evacuation come down to all the other hospitals which are not classified as type I CBRNe hospitals. Type II CBRNe hospitals should be able to take care of self-evacuations, as well as victims who do not require complex continuing care after decontamination at the disaster site or in a type I CBRNe hospital.

Preconditions to enable this organization of the hospital landscape are among others the integration of a CBRNe section in the hospital emergency plans, the alignment with the medical intervention plan, an increase of the training capacity of D2, and an increase of the awareness and expertise of call-takers and receptionists at ED.

For the **prehospital emergency response** we built on the principles of fast incident recognition and response, the importance of disrobing, the advantage of combining multiple decontamination interventions and the needs of (potential) victims. We propose to bring medical expertise in CBRNe and specialized medical equipment to the disaster site by means of mobile emergency services (CBRNe MUG-SMUR) which could be embedded in type I CBRNe hospitals or conceived as a standalone service. They should coordinate the triage, the set up the decontamination site, the decontamination process, staff rotation, and assist the DIR-MED in determining the priority of treatment and decontamination.

Decontamination is mainly organized at the disaster site because of the importance of the rapidity of the decontamination, the prevention of secondary contamination, and the difficulties in transporting contaminated victims. For victims who are life-threateningly injured (i.e. T1) dry decontamination on site is recommended and should be followed by immediate transport to the nearest type I CBRNe hospital. The decontamination of T2 and T3 victims should always start with an emergency disrobe and dry decontamination step (even with improvised means), which can already be carried out before the arrival of specialist resources to maximize the use of time during the earliest phases of an incident. Dry decontamination can be followed by wet decontamination on the disaster site, before the victim is transported to a hospital (if hospital care is needed). After wet decontamination, victims can be transported towards a type I or type II CBRNe hospital, depending on the complexity of the injuries and whether medical CBRNe expertise is needed for the treatment. The decision regarding the type of hospital should be taken by the DIR-MED in concertation with the medical expert-advisor on dangerous substances but procedures can be outlined in MIP.

Preconditions to the organization of prehospital emergency response are a CBRNe plan integrated in the MIP, the installation of a CBRNe team of medical expert-advisors on dangerous substances, sufficient training, expertise and awareness of 112 call-takers, sufficient (full-scale and) multidisciplinary disaster drills, an inventory and rotating stock of supplies, adequate information and communication systems, post-incidental follow-up, including registration and quantification of CBRNe victims, biomonitoring, evaluation of CBRNe incidents and drills, adequate financing of emergency planning and preparedness, integration of standard operating procedures regarding CBRNe events in the hospital emergency plan a shared vision about ethical considerations regarding the response to CBRNe emergencies and the development and implementation of a public preparedness plan.

RECOMMENDATIONS[g]

INTRODUCTION

A large number of actors and organisations is involved in dealing with CBRNe-incidents. CBRNe encompasses many types of incidents. Some types occur rarely but have the potential to cause significantly disruption to our hospitals and healthcare system. Other types of CBRNe incidents may occur more often, but can be handled by our current healthcare organisation.

A perfect preparation for this type of unpredictable incidents is not feasible. The desirability of the measures to be taken must therefore be weighed against other challenges facing our healthcare system, in a context where resources are scarce.

In this report, we examine the delivered emergency medical care both in hospitals and in the field. Our proposed healthcare organisation can improve the care for victims of CBRNe incidents and enhance the preparedness and resilience of the healthcare system in this context. We chose to start from and build on existing structures and expertise. The following recommendations should be interpreted in this light.

RECOMMENDATION 1: COORDINATED AND INTEGRATED POLICIES

To the Ministers of Health, Internal Affairs and Defence:

1.1 Organise an inter-ministerial conference with the relevant ministers of the federated entities, the High Official of the Brussels Agglomeration and the provincial governors concerning a coordinated and integrated approach to the management of CBRNe incidents. This should take into account the proposed organisation of the hospitals (see below) and the (strategic and/or operational) role assigned. Develop procedures specifically for this type of incidents, align them with the already existing emergency and intervention plans, and, if necessary, adapt the legal framework including, among others, efforts in the use of decontamination of CBRNe victims in the field, in the distribution of victims among the CBRNe Type I and Type II hospitals, in a regular and efficient training and education of the emergency workers involved in these incidents, etc.

1.2 Support the CBRNe Expertise Centre in its multidisciplinary mission for a coordinated and integrated approach to the management of CBRNe incidents in the context of further strengthening preparedness for such incidents.

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g The KCE has sole responsibility for the recommendations.

1.3 Develop a national registry of CBRNe incidents, conduct a systematic evaluation of each CBRNe incident, consolidate lessons learned and share them with all relevant actors e.g. through Paragon.

RECOMMENDATION 2: HOSPITAL PREPAREDNESS

To the Minister of Health, the FPS Public Health and the relevant ministers of the federated entities with their administrations:

We recommend to strengthen **hospital preparedness in the event of CBRNe incidents** in the following ways:

2.1 In order to clearly define the role of each hospital and to pool the existing expertise as much as possible, make a distinction between CBRNe Type I and Type II hospitals,

- **CBRNe Type II hospitals** should:
  a. Establish a standardised modus operandi in their hospital emergency plan for crowd control of potentially contaminated incoming victims of CBRNe incidents.
  b. Be able to initiate minimum proper decontamination for these victims outside their infrastructure, if necessary in coordination with other actors.
  c. In the case of severely injured contaminated and non-mobile casualties, immediately call the CBRNe mobile emergency group (MUG/SMUR) for specialised care and referral to CBRNe Type I hospitals.
  d. Be able to provide continued medical care to victims with mild injuries after decontamination; if specialised medical care is required based on the nature of the injuries, victims will be referred to the most appropriate care structure.
  e. Ensure the regular access to care at the same time.

- **CBRNe Type I hospitals**, in addition to what applies to CBRNe Type II hospitals, should also provide:
  a. Specialised (initial and continued) medical care for CBRNe casualties. Ideally, CBRNe Type I hospitals should have a reference centre for burns, a major trauma centre, a nuclear medicine service, a haematology service (with positive pressure chambers), an infectiology service (with negative pressure chambers), an emergency department capable of accommodating children, and a toxic substances lab.

b. A rotating stock of antidotes that can be deployed at their own facilities, but also in the field or in other hospitals.
c. A decontamination infrastructure for non-mobile seriously injured casualties, which can preferably also be used for other purposes (e.g. burn care).
d. A home base for specialists involved in an umbrella network of Medical Advisors on Hazardous Substances (to be created) that can be contacted 24/7. They should advise the Director of Emergency Medical Services (DIR-MED), emergency workers in Type II hospitals, the departmental crisis cell of the FPS Public Health, and possibly also the Risk Assessment Group (RAG), on the health effects of the hazardous substances, on the triage and treatment of casualties, on the protection of the population and on the organisation of care at the disaster site. The network is in direct contact with relevant stakeholders such as the CBRNe Expertise Centre and the Belgian Poison Centre.

2.2 Both CBRNe Type I and Type II hospitals should have a **stock of personal protective equipment** aligned with their assignments, and their staff should be trained to operate with it in the context of their role.

2.3 CBRNe Type I hospitals provide supra-regional care, and are **geographically spread** so as to ensure a short response time, but also taking into account the geographical distribution of the risk of CBRNe incidents.

2.4 For the prompt availability of medical expertise at the site of CBRNe incidents, on-site and/or in CBRNe Type II hospitals, the number of **CBRNe mobile emergency groups** (MUG/SMUR) can be scaled up. Ideally, they should be stationed at CBRNe Type I hospitals.

RECOMMENDATION 3: HOSPITAL EMERGENCY PLANS

To the FPS Public Health, the administrations of federated entities and hospital federations, we recommend:

3.1 Update the CBRN guidance for hospital emergency plans and support hospitals in the development of a CBRNe section in their hospital emergency plan, and in its transposition into their facilities. A CBRNe-specific section should be added to all hospital emergency plans already validated by the competent authorities. It should cover, in particular, the following aspects:

- A reception area for victims of a CBRNe incident outside the hospital buildings, indicated by clear, standardised signage.
- Standardised operational procedures (SOP) for among others, the internal division of tasks, patient management, decontamination of victims, staff capacity, personal protective equipment, waste management, mortuary management, communication, training and logistics.
- A procedure to safeguard regular care.

3.2 Strengthen the role of the hospital emergency plan coordinator to ensure proper implementation of the emergency plan.

3.3 Align the hospital emergency plans of the various hospital sites and hospitals within hospital networks and other organisational collaborations, and make sure they are in alignment with other emergency and intervention plans (e.g. the medical intervention plan (MIP)).

RECOMMENDATION 4: EDUCATION AND TRAINING

To the FPS Public Health

Endorse the organisation of continuing education and training, in cooperation with other relevant actors. These trainings should be accessible, preferably multidisciplinary, and adapted to the various actors involved in the management of CBRNe victims (e.g. 112 operators, 112 ambulance staff, nurses, emergency doctors, reception staff, etc.).

RECOMMENDATION 5: CAPACITY

To the Minister of Health and the FPS Public Health

When installing a national stockpile, set up an organisational structure based on clear choices. Develop a procedure that safeguards quick and easy accessibility (e.g. through real-time information transfer regarding capacity and location), with due regard for the confidential aspect of this stockpile.

RECOMMENDATION 6: COMMUNICATION AND INFORMATION

To the Ministers of Health and Internal Affairs, their administrations, and the NCCN:

6.1 Commit to the **further development of a uniform communication and information transfer system** (e.g. Paragon) taking the following considerations into account:

a. Provide a register of past and future disaster drills and trainings with a description and purpose of the exercise, the actors and the organisations involved, and the resulting points of action.
b. In cooperation with hospitals, set up a real-time overview of bed capacity, as well as the registration and follow-up of victims of CBRNe incidents (e.g. create a data link with the BITS registration system). Make victims of a CBRNe incident administratively visible in hospital data (e.g. in the RCM/MKG data).
c. Provide access to, and link with, information databases.

6.2 Provide a standardised **signage**, which can be placed at the entrance to each hospital site and in particular at the entrance to the emergency department, indicating the location where potentially contaminated victims can receive care. Inform citizens of the meaning of this signage, i.a. through Be-Alert.

6.3 Promote awareness of Be-Alert and other information channels. Develop a **public preparedness** plan, which should also cover the information of the public about protective measures and their effectiveness prior to an incident, and communicate this, among others, through Be-Alert.

6.4 Provide an **appropriate communication strategy** to the public that can be used in case of a CBRNe incident, taking into account the latest technological developments and social media.

6.5 In collaboration with relevant partners, deploy the rapid alerting of hospitals and first responders in the field (D1-D5), safeguarding real-time information and communication transmission so that they can prepare.

RECOMMENDATION 7: FOLLOW-UP

To the FPS Public Health, Sciensano and Fedris:

Biomonitor CBRNe victims and all other actors involved (emergency workers, neighbouring citizens, etc.) to assess and anticipate on (public) health consequences in the long run.

RECOMMENDATION 8: EUROPEAN COOPERATION

To authorities and actors involved in CBRNe incidents:

Further support and participate in European and cross-border initiatives such as joint actions, trainings, drills, education, etc.

RECOMMENDATION 9: ETHICS

To the FPS Public Health and the Advisory Committee on Bio-ethics:

Develop a shared vision on ethical considerations (e.g. regarding triage of victims) in CBRNe incidents and formulate advice that supports emergency responders in making ethically sound choices in situations where the demand for care exceeds the supply.

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