RAMPEN MANAGEMENT



ACADEMIEJAAR 2025-2026

CBRNe Preparedness in Belgium: Hospital Advancements,

Student Knowledge Gaps and Pathways Forward

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EXECUTIVE SUMMARY

Chemical, Biological, Radiological, Nuclear, and Explosive (CBRNe) incidents represent high-impact, low-probability threats that demand robust healthcare system resilience, particularly in vulnerable nations like Belgium with its dense industrial footprint, Seveso-class facilities, and geopolitical significance. Hospitals and future physicians form the frontline of response, yet historical gaps in preparedness, exposed by events like the COVID-19 pandemic and 2016 Brussels attacks, underscore the need for empirical reassessment. This postgraduate thesis in disaster management at Campus Vesta synthesizes two complementary studies: one evaluating hospital infrastructure and operations, the other establishing medical students' competence baseline, to inform tiered, education-integrated strategies.

Broader CBRNe Context

CBRNe events generate mass casualties, contamination, and societal disruption, positioning hospitals as critical response nodes, where deficiencies cascade into public health failures. Belgium's exposure, via chemical transport routes, nuclear proximity, and EU/NATO targets, amplifies risks, despite EU directives like HERA emphasizing harmonized standards. Curricular neglect in medical education further compounds institutional unevenness, as high trainee willingness clashes with knowledge deficits, mirroring international patterns.

Hospital Preparedness Progress

A nationwide cross-sectional survey (n = 56/91 hospitals, 61.5% response; December 2025-March 2026) adapted from Mortelmans et al. (2014) revealed substantial gains: 88% risk perception, 90% CBRNe plan integration (vs. 53%), 76% decontamination capacity (vs. 11%), universal class-4 PPE, and enhanced antidotes (e.g., hydroxocobalamin 96% vs. 47%). University hospitals excelled in decontamination capacity (ambulatory: 13.67/h vs. regional 2.56/h, $p < 0.001$), with 86% nuclear departments and 78% individual isolation. Persistent deficits included training (42% decontamination-ready staff), security (26%), advanced antidotes (pralidoxime 40%), and zero dedicated funding.

Student Knowledge Gaps

Among 419 master's students (KU Leuven/UAntwerpen, 18.5% response; September-December 2025), objective knowledge averaged 55% (mean score 12.09/22, SD 3.41), unchanged across years ($p = 0.082$). Self-rated competence was low (3.2/10), weakly correlating with scores ($\rho = 0.11$), while willingness to respond averaged 7.0/10 across scenarios (higher in seniors, $p < 0.001$). Structured prior exposure boosted scores modestly ($d = 0.25$-0.45); 57% deemed CBRNe curricular integration essential.

Synergistic Findings

Heterogeneity persists: hospitals advanced infrastructurally but falter operationally, while students' altruism outpaces skills, risking unsafe surge contributions. Self-reports limit validation; response biases and two-faculty restriction curb generalizability, yet longitudinal benchmarking strengthens validity.

Policy Recommendations

A tiered framework, reference university centres for surge/specialization, baseline competencies everywhere, addresses disparities, bolstered by simulation-validated training and funding. Integrating CBRNe electives (e.g., KU Leuven's Incident Management) capitalizes on student motivation, fostering a resilient pipeline aligned with national/EU resilience goals.

KEYWORDS

1. CBRNe preparedness
2. Hospital resilience
3. Medical education
4. Disaster medicine
5. Belgian healthcare

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GENERAL INTRODUCTION

Chemical, biological, radiological, nuclear, and explosive (CBRNe) incidents represent a class of low-probability but high-impact events that can place extreme pressure on healthcare systems. Their consequences may include mass casualties, contamination of hospital infrastructure, prolonged clinical follow-up, and disruption of routine emergency care. Because of these characteristics, CBRNe preparedness is not merely a technical or logistical issue; it is a core component of health-system resilience and national security.

In Belgium, this issue is especially relevant. The country's dense industrial landscape, Seveso-class facilities, transport of hazardous materials, and broader geopolitical exposure create a persistent background risk that requires sustained readiness rather than episodic attention. At the same time, preparedness cannot be reduced to the presence of equipment or written plans alone. A credible response to CBRNe incidents depends on the interaction between hospital infrastructure, organisational planning, trained personnel, and a workforce that understands how to respond safely under conditions of uncertainty.

This thesis therefore approaches CBRNe preparedness as a continuum that extends across time and across stages of professional development. This study resulted in two research papers addressing different aspects of CBRNe preparedness. The first paper evaluates past and present preparedness by comparing the current state of Belgian hospital readiness with a baseline survey conducted more than a decade earlier. The second one focuses on the future workforce by assessing the CBRNe knowledge, self-perceived preparedness, and willingness to respond among Belgian medical students, who will form the next generation of physicians. Taken together, these studies allow preparedness to be examined not as a static snapshot, but as an evolving system that must be maintained, renewed, and transmitted across generations.

RATIONALE

The hospital study is important because it captures whether preparedness has progressed over time. A comparison with earlier data makes it possible to determine whether Belgian hospitals have translated increased awareness and policy attention into concrete operational improvements. Such a longitudinal perspective is essential in disaster medicine, where readiness may change slowly and unevenly across institutions, even after major societal events have heightened awareness. By examining current hospital preparedness in relation to the earlier baseline, this study evaluates the extent to which Belgian hospitals have moved from vulnerability toward greater resilience, and which domains still require further strengthening.

The student study is equally important because it shifts attention to the future. Hospitals can only function effectively in a CBRNe event if they are staffed by clinicians who possess the basic knowledge, confidence, and practical judgment required to recognize hazards, protect themselves, and initiate appropriate measures. Medical students therefore represent the future capacity of the health system. If their CBRNe knowledge remains limited during training, then future hospitals will inherit a workforce that may be willing to help but insufficiently prepared

to do so effectively. In that sense, the student study examines not only present educational gaps, but also the sustainability of preparedness over time.

The combination of these two perspectives is scientifically and practically valuable. Hospital preparedness reflects the current state of response capacity, whereas student preparedness reflects the future state of that capacity. A system can only be considered truly prepared when both are aligned. Hospitals may have decontamination units, protocols, antidotes, and specialist access, but those resources are only useful if personnel can apply them appropriately. Likewise, medical students may demonstrate motivation and professional commitment, but without structured CBRNe education, that willingness does not automatically translate into competence.

RESEARCH QUESTIONS

The central problem addressed in this thesis is that Belgian CBRNe preparedness may be improving, but not in a fully integrated way. On the one hand, hospitals appear to have made progress since the earlier baseline survey, suggesting meaningful advancement in institutional readiness. On the other hand, medical students still demonstrate clear knowledge gaps despite strong willingness to engage in CBRNe response, indicating that the future workforce is not yet fully equipped. These two findings point to a broader challenge: preparedness must be developed simultaneously at the level of systems and at the level of education.

This thesis therefore asks two complementary questions.

Research question 1: **To what extent are Belgian hospitals with an emergency department prepared for CBRNe incidents, and what progress has been made compared with the earlier baseline survey?**

Research question 2: **What is the baseline level of objective CBRNe knowledge among Belgian master's medical students? How do Belgian master's medical students perceive their own CBRNe preparedness, and how willing are they to participate in the care of patients during CBRNe incidents?**

This two-paper design is justified because CBRNe preparedness is not limited to emergency plans or teaching content alone. It is a system-level challenge that requires continuity between past investments, present capacities, and future workforce development. By examining hospitals and medical students within one framework, this thesis links operational preparedness with educational preparedness and thereby offers a more comprehensive assessment of Belgian resilience to CBRNe incidents. Such an approach is particularly relevant in a high-impact domain where the consequences of inadequate preparation may be immediate, severe, and difficult to reverse.

PART 1: ASSESSING PROGRESS IN HOSPITAL CBRN PREPAREDNESS IN BELGIUM: COMPARISON WITH A BASELINE STUDY CONDUCTED OVER A DECADE AGO

ABSTRACT

Study objective. Chemical, biological, radiological and nuclear (CBRN) incidents are high-impact, low-probability events with potentially severe public health consequences. Hospitals play a critical role in responding to such incidents and must maintain adequate preparedness. Previous research by Mortelmans et al. in 2014 identified substantial gaps in hospital readiness, and subsequent events, including the COVID-19 pandemic, have further exposed systemic vulnerabilities. This study aims to evaluate whether preparedness has improved over time and to identify remaining gaps relevant to hospital disaster planning and national resilience.

Methods. A national cross-sectional survey (December 2025-March 2026) was distributed to all Belgian hospitals with accredited emergency departments. The questionnaire (available in Dutch, French, and English) assessed governance, risk perception, decontamination capacity, personal protective equipment (PPE), antidotes, specialist availability, isolation capacity, and funding. Descriptive and inferential analyses (t-tests and one-way ANOVA) were performed using SPSS 30.0.

Results. Fifty-six of 91 hospitals participated (61.5% response rate: 54% regional, 28% supraregional, 18% university). Most hospitals perceived themselves at risk of CBRN incidents (88%), and 90% integrated CBRN scenarios into disaster plans. Decontamination capacity was reported by 76% of hospitals but with only 42% citing adequate staff training and 26% having dedicated area security. PPE of classes 3-4 was widely available, whereas class 1-2 was less frequent. University hospitals had significantly higher decontamination throughput ($p < 0.001$). No dedicated funding for CBRN preparedness was reported.

Conclusion. Belgian hospitals have considerably advanced in CBRN readiness over the last decade, but preparedness remains uneven across hospital types. Findings support establishing a tiered national preparedness framework with designated reference centres and universal baseline capability standards across all emergency departments.

INTRODUCTION

Chemical, biological, radiological, and nuclear (CBRN) incidents, whether accidental, deliberate, or hybrid in nature, pose complex, low-probability but high-impact threats to healthcare systems (World Health Organization Regional Office for Europe, 2025; Trapp et al., 2021). Such incidents may generate mass casualties, prolonged health consequences, environmental contamination, and extensive societal disruption. Hospitals serve as terminal nodes in the national response chain, where failures may result in cascading public health consequences (Rega, 2022). Consequently, hospital-level CBRN preparedness is widely recognised as a cornerstone of national health security and societal resilience (Cornelis et al., 2024).

Belgium represents a particularly exposed environment: it combines high industrial density (Seveso-class facilities), major chemical transport routes, and symbolic geopolitical targets such as EU and NATO headquarters. Despite strategic awareness, operational CBRN readiness at hospital level historically suffered from fragmentation, inconsistent governance, and insufficient training investment (Mortelmans et al., 2014; European Commission, 2025).

The COVID-19 pandemic and recent European security crises have underscored the significance of flexible health emergency preparedness systems (World Health Organization Regional Office for Europe, 2025; Nationaal Crisiscentrum (NCCN), 2024; Eyison et al., 2020). Although several EU initiatives now stress hospital resilience as part of integrated CBRN risk management, practical implementation data remain scarce (European Comission, 2023; HERA & Deville, 2026; Mortelmans et al., 2014; Barten et al., 2024).

This study updates the national CBRN preparedness assessment using a methodology adapted from Mortelmans et al. (2014) to determine progress, identify persistent gaps, and guide policy towards sustainable system resilience.

METHODS

PARTICIPANTS AND RECRUITMENT

The study population included all Belgian hospitals with an accredited emergency department active in 2025. Heads of emergency medicine served as primary respondents due to their central role in both campus-level operations and network-wide disaster coordination.

Recruitment was coordinated by University Hospitals Leuven via email invitations with telephone follow-up. Data collection was conducted over a four-month period, from early December 2025 through late March 2026.

Recent hospital mergers in Belgium have led to multi-campus hospital groups, where specialized emergency departments are often centralised on one campus or distributed across multiple sites within the network. When hospitals within multi-campus networks participated, they typically submitted a single consolidated response representing preparedness across the entire group. These were counted as single units in the analysis.

STUDY DESIGN

This study employed a national, cross-sectional survey design to evaluate hospital-level preparedness for chemical, biological, radiological, and nuclear (CBRN) incidents in Belgium. The survey targeted all hospitals operating a formally accredited emergency department, as these institutions represent the designated entry points for casualties in large-scale emergencies and serve as critical nodes in national response systems.

QUESTIONNAIRE DESIGN

The questionnaire was adapted from a survey previously used to assess hospital CBRN preparedness, thereby permitting longitudinal comparison of preparedness indicators. The updated instrument encompassed multiple domains of hospital readiness, including planning, training, governance, infrastructure, and resource availability. To ensure linguistic accessibility across regions, the survey was made available in Dutch, French, and English. It was administered electronically via the LimeSurvey platform.

Survey content addressed the inclusion of CBRN-specific components within hospital emergency and disaster management plans, the frequency and scope of staff training on CBRN scenarios, and the availability of essential technical and infrastructural capacities (e.g., decontamination units, detection and monitoring devices). Additional items captured information on the stockpiling of critical medical countermeasures, such as antidotes and the availability of specialised expertise (e.g., infectious disease, toxicology, or nuclear medicine consultation). Respondents were also asked about funding structures dedicated to CBRN preparedness.

DATA ANALYSIS

Data were analysed using SPSS (version 30.0, IBM Corp., Armonk, NY, USA). Descriptive statistics were calculated for all preparedness indicators, expressed as absolute frequencies, percentages, means, and standard deviations as appropriate. Normality of continuous variables was assessed using visual inspection and the Shapiro–Wilk test. Group comparisons were conducted using one-way analysis of variance (ANOVA), as applicable. A significance threshold of $p < 0.05$ was applied for all inferential analyses. Missing data were handled by pairwise deletion.

ETHICAL CONSIDERATIONS

The study protocol was approved by the Institutional Review Board of the Catholic University of Leuven, Belgium (reference MP031696). Participation was voluntary. Because no personally identifiable data were collected, the requirement for written informed consent was waived. Completion and submission of the questionnaire were considered to imply consent for participation. All participants received written information outlining the study's purpose, data handling procedures, and intended use of the results.

RESULTS

The survey was conducted between november 2025 and march 2026 and targeted Belgian hospitals equipped with an emergency department. In total, 91 institutions were invited to participate. The overall response rate was 61,5% (n = 56 of 91). These hospitals identified as regional in 54%, supraregional in 28% and university hospitals in 18%.

RISK PERCEPTION

A total of 88% of hospitals perceived themselves to be at risk for a chemical, biological, radiological, or nuclear (CBRN) incident, while 10% did not perceive such a risk and 2% were uncertain. Proximal chemical hazards, including nearby Seveso-classified industrial facilities, were reported by 86% of respondents. Nuclear hazards in the vicinity of the hospital were identified by 38% of participants, and 60% reported additional potential threats, including proximity to possible terrorist targets (**Table 1**).

DISASTER PLANS AND PREPARATION

The emergency department contributed to the development of the hospital disaster plan in 96% of hospitals. CBRN scenarios were explicitly incorporated into the disaster plan in 90% of institutions. Provisions for the mobilization of additional staff were included in 94% of plans, whereas 56% specified procedures for personnel with dedicated CBRN expertise. Strategies for mobilizing additional material resources were described in 66% of plans, and 72% of hospitals reported mechanisms to expand bed capacity during an incident (**Table 1**)..

	% yes/positive answer
(1) CBRNe Incident risk	
· Chemical risk factor (Seveso) in hospital sector?	86 %
· Nuclear installation in hospital sector?	38 %
· Other risks (e.g. terrorism target)?	60 %
(2) Hospital disaster plan	
· Emergency department participates in hospital disaster plan?	96 %
· CBRNe scenario included in the plan?	
· Are there regulations for:	90 %
o Mobilization of extra personnel?	
o Mobilization of extra staff with specific expertise in CBRN?	94 %
o Mobilization of extra supplies?	56 %
o Creation of extra bed capacity?	
	66 %
	72 %

(3) Decontamination	
· Decontamination facilities available?	76 %
o permanently available?	54 %
o available on demand?	24 %
· In front of/at the entrance of the ED?	70 %
· Max. capacity per hour for walking patients?	6 /h
· Max. capacity per hour for supine patients?	2 /h
· Is there isolated waste treatment?	60 %
· Is staff trained in decontaminating?	42 %
· Security personnel to control decontamination?	26 %
(4) Personal Protective Equipment (PPE)	
Available PPE classes	
· 1: Full body containing chemical suit with self-contained breathing apparatus (SCBA)	50 %
· 2: Chemical splash suit, canister, air purifier, face mask	74 %
· 3: Gloves, gown, goggles, and N95 respirator mask	
· 4: Gloves, gown, goggles, and surgical mask	96 %
· Is your staff trained to use them?	
	100 %
	72 %
(5) Antidotes	
Available antidotes	
· Atropine	100 %
· Calcium gluconate	98 %
· Ethanol	46 %
· Flumazenil	92 %
· Glucagon	98 %
· Hydroxycobolamine	96 %
· N-acetylcysteine	98 %
· Naloxone	100 %
· Pralidoxime/obidoxime	40 %
· Thiosulphate	44 %
(6) Radiation/nuclear threats	
· Nuclear medicine department in hospital?	86 %
· Nuclear medicine specialist 24/7 available?	50 %
· Radiation detection probes with alarm available?	60 %
· Type of radiation possible to measure?	
o Alpha	78 %
o Beta	76 %
o Gamma	56 %
(7) Biological threats	
· Infectiologists/microbiologists 24/7 available?	58 %
· Facilities for medical isolation in the ED?	
o Individual	78 %
o Collective	54 %
(8) Financial support	
· Any financial support to enhance CBRNe preparedness?	0%

Table 1: *Schematic overview of the questions used in the survey to assess CBRN(e) preparedness of Belgian hospitals and percentage of positive answers (e.g. meaning a specific characteristic or facility is available). Full survey questions are included in the supplementary materials.*

DECONTAMINATION

Overall, 76% of hospitals reported having decontamination capacity. These facilities were permanently available in 54% of hospitals and at least partially deployable on call in 24%. In 70% of hospitals, decontamination facilities were located at or near the emergency department entrance. Separate waste management systems for potentially contaminated water were available in 60% of hospitals. However, only 42% reported adequate staff training for the use of decontamination facilities, and 26% had dedicated security arrangements for the decontamination area. Mean decontamination capacity was 2 supine patients per hour and 6 ambulatory patients per hour (**Table 1**)..

Decontamination capacity differed significantly by hospital type. For ambulatory patients, one-way ANOVA demonstrated a significant effect of hospital type ($p < .001$), with mean capacities of 2.56 patients/h in regional hospitals, 5.93 patients/h in supraregional hospitals, and 13.67 patients/h in university hospitals. Games-Howell post hoc analysis revealed significant differences between regional and supraregional hospitals ($p = .002$) and between regional and university hospitals ($p = .031$), while the difference between supraregional and university hospitals was not statistically significant ($p = .132$).

For supine patients, a significant effect of hospital type was also observed ($p < .001$), with mean capacities of 1.22 patients/h in regional hospitals, 2.93 patients/h in supraregional hospitals, and 4.56 patients/h in university hospitals. Post hoc testing showed a significant difference between regional and supraregional hospitals ($p = .004$), whereas the other pairwise comparisons did not reach statistical significance ($p = .065$ and $p = .455$).

PERSONAL PROTECTIVE EQUIPMENT AND ANTIDOTES

Availability of personal protective equipment (PPE) varied by protection level. Class 1 PPE was available in 50% of hospitals, class 2 in 74%, class 3 in 96%, and class 4 in all hospitals (100%). **Table 2** gives a description of the different classes of PPEs.

PPE Class	Descirption
1	Full body containing chemical suit with self-contained breathing apparatus (SCBA)
2	Chemical splash suit, canister, air purifier, face mask
3	Gloves, gown, goggles, and N95 respirator mask
4	Gloves, gown, goggles, and surgical mask

Table 2*: Exemplary description of different classes of Personal Protective Equipment (PPEs).*

Atropine and naloxone were universally available across all institutions. Availability of other antidotes was high for most agents, including N-acetylcysteine (98%), hydroxycobalamin (96%), glucagon (98%), calcium gluconate (98%), and flumazenil (92%). In contrast, ethanol, thiosulfate, and pralidoxime were less frequently available, reported by 46%, 44%, and 40% of hospitals, respectively (**figure 1, table 1 and 3**).

Antidote	Current antidote availability (%)	Mortelmans et al. (2014)
Atropine	100	100
Naloxone	100	89
Calciumgluconate	98	79
Glucagon	98	81
N-acetylcystein	98	84
Hydroxycobalamin	96	47
Flumazenil	92	83
Ethanol	46	62
Thiosulfate	44	47
Pralidoxime	40	19

***Table 3**: Comparison of antidote availability, expressed as the percentage of hospitals, between current study and previous survey by Mortelmans et al. (2014).*

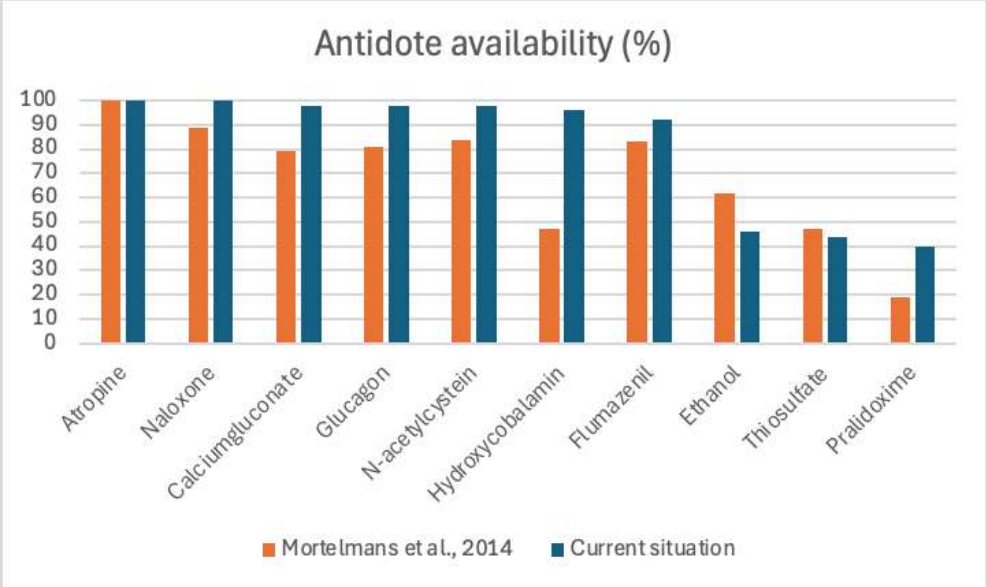


***Figure 1:** Antidote availability expressed as the percentage of hospitals having the antidote readily available. Comparison between current survey and previous work by Mortelmans et al. (2014).*

SPECIALIZED EXPERTISE, DETECTION, AND ISOLATION

A nuclear medicine department was present in 86% of hospitals, with 50% reporting 24/7 availability of a nuclear medicine specialist. Radiation detection equipment was available in 60% of hospitals; among these, 78% could detect alpha radiation, 76% beta radiation, and 56% gamma radiation. Continuous (24/7) access to an infectious disease or microbiology specialist was reported by 58% of hospitals. Isolation capacity within the emergency department was variable: 78% of hospitals reported availability of individual isolation facilities, 54% reported collective isolation capacity, and 16% indicated no isolation capacity. None of the hospitals reported receiving dedicated financial support for CBRNe preparedness (**Table 1**)..

DISCUSSION

This survey indicates that CBRN preparedness in Belgian hospitals has improved substantially over the past decade, yet remains heterogeneous and incomplete. Compared with the 2014 study by Mortelmans et al., gains are evident in disaster planning, decontamination capacity, PPE availability, and access to specialist expertise. However, persistent gaps, particularly in staff training, decontamination security, and advanced radiological capabilities, suggest partial rather than comprehensive readiness.

A key finding is the pronounced variability between hospital types. University hospitals consistently demonstrated higher decontamination capacity than regional hospitals, with supraregional centres occupying an intermediate position. This gradient extended beyond infrastructure to specialist availability and operational readiness. Given the low-frequency, high-complexity nature of CBRN incidents, such disparities are clinically significant, as fragmented capabilities may compromise timely and safe response. Preparedness appears to depend less on hospital size alone than on the availability of dedicated resources, expertise, and sustained training.

Temporal comparison reinforces this interpretation. In 2014, only 53% of hospitals incorporated CBRN scenarios in disaster plans, 11% reported decontamination capacity, and 6% had adequate PPE for hazardous triage. The markedly higher proportions observed in the present study likely reflect increased awareness driven by events such as the 2016 Brussels attacks and the COVID-19 pandemic (Rega, 2022; Hupf et al., 2024). Nevertheless, the persistence of inter-hospital variability indicates uneven implementation of preparedness measures.

Comparable studies in Germany and France have reported analogous patterns, where tertiary centres achieve higher CBRN readiness while smaller institutions lag behind (Hupf et al., 2024).

POLICY IMPLICATIONS

These findings support consideration of a tiered, partially centralized model of CBRN preparedness. Concentrating advanced capabilities in designated reference centres (analogous to level 1 trauma systems) could improve quality, standardization, and sustainability. Such centres would maintain specialized infrastructure, multidisciplinary expertise, and surge capacity, while coordinating regional response. At the same time, all hospitals must retain baseline competencies, including early recognition, initial isolation, staff protection, and safe transfer pathways, given the likelihood of self-presenting patients.

These standards could either be set at the nation level or EU-level initiatives such as Health Emergency Preparedness and Response (HERA) and the EU Health Security Committee could facilitate harmonized minimum standards and funding channels.

Future work should include functional exercises and simulation-based validation to move beyond self-reporting.

LIMITATIONS

Findings rely on self-reported data and may not reflect actual operational performance under stress. Some hospitals may interpret “adequate preparedness” inconsistently. Response bias and modest sample size limit generalizability. Nonetheless, national coverage and longitudinal comparison confer substantial external validity.

CONCLUSION

This reassessment demonstrates major progress in Belgian hospital CBRN preparedness over the past decade but reveals persistent variability and underinvestment. A tiered, nationally coordinated model, anchored by university reference centres and uniform baseline requirements, offers a pragmatic path to enhance overall resilience and alignment with European emergency preparedness frameworks.

PART 2: IDENTIFYING GAPS IN MEDICAL STUDENT CBRNE COMPETENCE: A CROSS-SECTIONAL SURVEY SUPPORTING TARGETED TRAINING

ABSTRACT

Introduction/study objective. Chemical, biological, radiological, nuclear, and explosive (CBRNe) incidents are high-impact, low-probability events with severe public health consequences. Despite low perceived risk in Belgium, vulnerabilities like Seveso sites and geopolitical threats necessitate medical preparedness. Prior studies indicate insufficient CBRNe integration in medical curricula. This study assessed Belgian medical students' baseline objective knowledge, self-perceived preparedness, and willingness to assist in CBRNe incidents ahead of a new elective course.

Methods. A cross-sectional, anonymous online survey (LimeSurvey) targeted master's medicine students at Belgian faculties (Sep-Dec 2025). It covered demographics, self-rated knowledge/preparedness, prior experience, willingness in CBRNe scenarios (0-10 scale), and objective knowledge via 16 MCQs + 5 case scenarios (max score 22). Data analyzed descriptively and inferentially in SPSS v30.

Results. A total of 419 students participated (response rate 18.5%, mean age 22.6y). The mean knowledge score was 12.09 (55%, SD 3.41), with no significant differences across years of study ($p = 0.082$). Self-perceived knowledge was low (mean 3.16/10) and showed only weak correlations with objective knowledge and willingness to assist. Despite limited knowledge, students reported high willingness to engage in CBRNe incidents (7.01/10), consistent across chemical, biological, radiological, and nuclear scenarios. Certain prior experiences were associated with modestly higher knowledge scores.

Conclusion. Belgian medical students demonstrate a clear discrepancy between high willingness to assist in CBRNe incidents (7/10) and limited objective knowledge (55% correct), establishing a baseline gap for targeted training evaluation.

INTRODUCTION

Problem. CBRNe (chemical, biological, radiological, nuclear, and explosive) incidents, whether accidental or intentional, pose a disproportionate threat to public health (Canada Health, 2005; DC Health, 2026; European Union, 2025; Nationaal Crisiscentrum (NCCN), 2026c; NPSA, 2026). They are typically classified as high-impact, low-probability events due to their potential to cause mass casualties, long-term health effects, environmental contamination, and extensive societal disruption (Coleman et al., 2019; Trapp et al., 2021). Although the probability of such incidents occurring in Belgium is considered very low, the country's high density of Seveso-class industrial facilities and extensive petrochemical transport networks create a distinct vulnerability (Belgium Sealogis Freight Forwarding, 2026; Nationaal Crisiscentrum (NCCN), 2026a, 2026b; Toxic Software, 2026). Recent geopolitical developments and the consequent rise in European concern regarding CBRNe threats have further underscored the strategic importance of national health-sector preparedness (Christiaens et al., 2023; Qzih & Ahmad, 2024).

Gap. An effective medical response to CBRNe incidents requires specialised competencies, including scene safety, appropriate use of personal protective equipment, decontamination procedures, triage systems, and familiarity with specific antidotes. However, these essential skills are insufficiently embedded in medical curricula and are frequently dispersed across discipline-specific modules. Evidence from multiple countries indicates that both medical students and physicians report limited knowledge and low self-perceived preparedness for CBRNe emergencies (Mortelmans et al., 2013, 2015; Qzih & Ahmad, 2024; Rahman et al., 2024; Sheikhi et al., 2025). In contrast, structured, exercise-based training approaches, such as those used in military training settings, are associated with substantially higher levels of preparedness (Center for Domestic Preparedness, 2026; Křivohlavá, 2024; Mortelmans et al., 2016). Despite national and European policy directives advocating enhanced CBRNe-related education, comprehensive training initiatives within civilian medical programmes remain limited.

Objective. Recently, coordinated discussions took place between the Belgian Ministry of Defence and all national medical faculties to explore ways of strengthening civil–military collaboration in disaster and CBRNe preparedness education. As an outcome of this dialogue, several universities expressed interest in integrating military and disaster medicine principles into their curricula. At KU Leuven, this initiative will materialize through the introduction of a new elective course, Incident Management, available from the next academic year, addressing core themes of CBRNe response and intersectoral coordination.

The present study aims to establish a baseline assessment of medical students' current knowledge, competencies, and perceived preparedness for managing CBRNe incidents. By identifying existing gaps early in the training pathway, the study seeks to clarify the extent of the emerging need for dedicated CBRNe education within undergraduate medical programmes.

METHODS

STUDY DESIGN

A cross-sectional survey design was used. Data were collected anonymously through the LimeSurvey online platform between 15th of September and 15th of December 2025.

PARTICIPANTS AND RECRUITMENT

All master of medicine students enrolled at any Belgian medical faculty, as well as master's students following their training via the military, were eligible for inclusion. Faculties received an invitation email containing a short cover text and a link to the online survey, which was available in Dutch, French and English via LimeSurvey.

If no reply or distribution confirmation was obtained, reminder emails were sent. At KU Leuven, the study was additionally presented in lecture halls after classes; students could participate immediately by scanning a QR code that linked to the survey. To further enhance reach, the Belgian Medical Students' Association (BeMSA) and medical student year-group pages on Facebook were contacted and asked to disseminate the survey.

Final-year students, who were predominantly on clinical rotations and therefore less accessible on campus, were specifically targeted through electronic channels, including faculty mailing lists and social media, to encourage participation.

QUESTIONNAIRE DESIGN

The questionnaire was designed based on prior research in disaster medicine and CBRNe preparedness and was specifically adapted to the Belgian context (Mortelmans et al., 2013, 2015; Smout et al., 2023). The first section captured demographic data, including age, year of study, university affiliation, and intended career path (e.g., general practice, specialty training, or other). This section further assessed participants' place of residence relative to nuclear facilities, Seveso-classified sites, or other high-risk locations. Additionally, information on prior experience and training related to CBRNe incidents, as well as self-reported knowledge, was collected using Likert-scale items. Participants' perceived need for inclusion of CBRNe-related content in the medical curriculum was also evaluated.

The second section explored students' motivation and willingness to provide care in a series of predefined CBRNe incident scenarios. The final section comprised a knowledge assessment, including 16 theoretical multiple-choice questions and 5 short case-based scenarios, designed to evaluate understanding of essential principles, including triage, identification of potentially hazardous situations, and basic clinical management.

STATISTICAL ANALYSIS

Data were exported from LimeSurvey and analyzed using SPSS (version 30.0, IBM Corp., Armonk, NY, USA). The distribution of continuous variables was assessed both graphically (histograms and Q-Q plots) and using the Shapiro–Wilk test.

Continuous variables were summarized as means with standard deviations or medians with interquartile ranges, depending on their distribution. For subgroup comparisons, two-sided independent-samples t-tests or one-way analysis of variance (ANOVA) were applied as appropriate. A p-value < 0.05 was considered statistically significant.

ETHICAL APPROVAL

The study protocol was approved by the Institutional Review Board of the Catholic University of Leuven, Belgium (reference MP031696). Participation was voluntary and anonymous, and completion of the online questionnaire was considered to imply informed consent.

The introductory text preceding the survey clearly outlined the study objectives, the nature of the questions, and the procedures for data storage, analysis, and reporting. No personally identifiable information was collected, and participants were free to withdraw from the survey at any time without any consequences.

RESULTS

PARTICIPANT CHARACTERISTICS

All Belgian medical faculties offering a master's degree were invited to participate via email. However, several institutions maintained internal policies against distributing external survey invitations to students, which limited outreach efforts. Due to these institutional limitations, only students from UAntwerpen and KULeuven participated, yielding a total response rate of 18.48%.

The final sample comprised 419 medical students with complete data. Table 1 details demographics and details of the participants. Mean age was 22.6 years. Respondents were distributed across master's years as follows: 1st Master's 38%, 2nd Master's 38% and 3rd Master's 24%. Reported specialty interests (multiple responses permitted) were: Family Medicine 46%, Emergency Medicine 46%, Anesthesiology 18%, Internal Medicine 16%, Nuclear Medicine 7%, Infectiology 6% and other specialties 54% (predominantly surgical fields and Pediatrics). Only 1% of participants reported having received medical training through Defence services (**Table 4**).

Proximity to potentially hazardous installations varied: 22% lived within 20 km of a nuclear facility, 22% within 20 km of a chemical (Seveso) site, 58% did not live near a nuclear installation, and 24% did not live near a chemical site, with the remainder uncertain. Approximately 20% reported prior experience in emergency or disaster medicine, and 23% reported at least some knowledge of disaster medicine. When asked about integrating disaster medicine into the medical curriculum, 57% regarded it as absolutely necessary and 43% as useful, while none considered it unnecessary (**Table 4**).

This profile outlines the demographic and academic composition of Belgian medical students, their specialty interests, and their prior exposure relevant to CBRNe preparedness, while also reflecting institutional and logistical barriers that influenced participation rates.

Mean age (total range)		**22.60** (20-37) years	
		N	**(%)**
Study year	4th (1st Master's)	159	(38 %)
	5th (2nd Master's)	159	(38 %)
	6th (3rd Master's)	101	(24 %)
Interest in future orientation *(multiple answers possible)*	Family Medicine	193	(46 %)
	Emergency Medicine	191	(46 %)
	Anesthesiology	75	(18 %)
	Internal Medicine	67	(16 %)
	Nuclear Medicine	30	(7 %)
	Infectiology	25	(6 %)
	Other specialties *(e.g. surgical fields, pediatrics)*	225	(54 %)

Medical training via Defence		3	(1 %)
Lives within 20 km of nuclear installation	Yes	94	(22 %)
	No	245	(58 %)
	Don't know	80	(19 %)
Lives withing 20 km of chemical installation (Seveso)	Yes	93	(22 %)
	No	99	(24 %)
	Don't know	227	(54 %)
Has any EM/DM experience	Yes	83	(20 %)
	No	336	(80 %)
Has some DM knowledge	Yes	95	(23 %)
	No	324	(77 %)
DM needs to be trained within curriculum	Absolutely	237	(57 %)
	Useful	182	(43 %)
	No/useless	0	(0 %)

***Table 4**: Summary of participant characteristics (n=419), including demographics, master's year distribution, specialty interests, prior experiences, and proximity to hazards.*

OBJECTIVE CBRNE KNOWLEDGE

The CBRNe knowledge test had a maximum score of 22 points, and students achieved a mean score of 12.09 (SD = 3.41), corresponding to approximately 55% correct answers and indicating limited objective knowledge. Table 4 reveals correct response rates per question, identifying gaps in decontamination, radiation principles, and triage (many <50%) (**Table 5**).

Normality of scores was examined using Shapiro-Wilk tests and visual inspection of histograms and Q-Q plots. Although Shapiro-Wilk tests were significant for all training years ($p < .05$), suggesting deviations from perfect normality, Q-Q plots indicated that these deviations were small and predominantly confined to the distribution tails. Levene's test indicated heterogeneity of variances ($p < .05$), so Welch's ANOVA, which is robust to both non-normality and unequal variances, was used for group comparisons.

Mean knowledge scores were similar across master years (year 1: 12.63; year 2: 11.77; year 3: 11.75), and Welch's ANOVA showed no statistically significant differences between groups ($p = .082$, $\omega^2 \approx 0.01$), with post hoc pairwise comparisons confirming the absence of significant differences. Consistently, Spearman's correlation showed no meaningful association between year of study and objective knowledge ($\rho = -0.06$, $p = 0.20$), indicating that progression through the master's programme was not associated with higher CBRNe test performance.

Q1	**Chain collision, possible chemical contamination of patients**	
	Isolate in distal corner	3 %
	In waiting room	13 %
	In garage	8 %
	Wait separately outside and call supervisor	***77 %***
	No action, hide	0 %
Q2	**Iodine tablets protect against**	
	External radiation	22 %
	Internal radiation	***47 %***
	Both external and internal radiation	18 %
	No radiation protection	10 %
	Don't know	4 %
Q3	**Postman with necrotic lesion in the ER**	
	Frostbite	15 %
	New chemical product	16 %
	Possible anthrax	***45 %***
	New type of black ink	0 %
	Don't know	24 %
Q4	**Decontamination after chemical incident**	
	Oral antidote	1 %
	Specific antidote ointment	6 %
	Antidote spray by special military cabin	29 %
	Wash/shower with water and soap	***45 %***
	Don't know	19 %
Q5	**Best way to limit radiation damage**	
	Use of PPE	4 %
	Rapid decontamination	3 %
	Oral iodine tablets	2 %
	Limit exposure time, increase distance and shielding	***89 %***
	Don't know	2 %
Q6	**2 most important objects to take along in evacuation (select 2)**	
	Smartphone	39 %
	Laptop	1 %
	ID/health insurance card	***73 %***
	Drinks/food	35 %
	Medication or list of medication	***51 %***
	Photo of a loved one	0 %
	None of the above	0 %
	Don't know	0 %
Q7	**Explosion, 3 friends superficial cuts and 1st degree burns. Go to**	
	Nearest hospital	47 %
	Closest hospital with specialized burn unit	10 %
	Home (recover and sleep)	1 %
	Hospital ER further away	***41 %***
	Don't know	0 %
Q8	**First step in decontamination in nuclear incident**	
	Shower	8 %
	Iodine tablet	11 %
	Remove clothing and shoes	***68 %***
	Put on lead apron	2 %
	Don't know	11 %

Q9	**Traffic accident with 2 tanker trucks, 2 victims, what to do?**	
	Stop, call 112, help lying victim	6 %
	Stop, call 112, help limping victim	5 %
	Stop at safe distance, cal 112, wait for clearence fire brigade	***89 %***
	Drive by and call 112 as soon as possible	0 %
	Drive by as if nothing happened	0 %
Q10	**What is secondary contamination**	
	Contaminated persons/objects are touched	12 %
	Contact with hazardous substances settled on materials	6 %
	Eating/drinking contaminated food or drinks	0 %
	Inhalation of exhaled air from victims	0 %
	All of the above	***60 %***
	None of the above	1 %
	Don't know	21 %
Q11	**Physical state of substance with highest absorption through skin**	
	Solid	0 %
	Liquid	***56 %***
	Gas	30 %
	Don't know	13 %
Q12	**In nuclear incident, all exposed are contaminated**	
	True	34 %
	False	***40 %***
	Don't know	26 %
Q13	**Anthrax profylaxis, administer**	
	Antidote	11 %
	Antibiotic	***51 %***
	Antiviral medication	3 %
	Antifungal medication	2 %
	Don't know	32 %
Q14	**Most difficult type of radiation to detect in contaminated patient**	
	Alpha	***22 %***
	Beta	4 %
	Gamma	28 %
	Don't know	46 %
Q15	**Primary route internal contamination in nuclear incident**	
	Inhalation	***41 %***
	Absorption skin	34 %
	Ingestion	10 %
	Don't know	15 %
Q16	**Rapid treatment with oxygen for which chemical agent**	
	Corrosive agents	11 %
	Vesicant agenst	4 %
	Blood agents	***36 %***
	Don't know	49 %
Q17	**Atropine is antidote for**	
	Nerve agents	***42 %***
	Choking agents	4 %
	Vesicant agents	4 %
	All of the above	2 %
	Don't know	48 %

Q18	**Which chemical gives burns in the airways? (multiple answers)**	
	Sulfuric acid	***67 %***
	Sarin (nerve gas)	24 %
	Cyanide	17 %
	Gasoline	26 %
	Bases	***35 %***
	Don't know	23 %
Q19	**Everyone must ingest iodine tablet after nuclear incident**	
	True	36 %
	False	***57 %***
	Don't know	7 %
Q20	**Visible substance on patient's skin, always rinse with water**	
	True	5 %
	False	***80 %***
	Don't know	15 %
Q21	**Match correct name with correct hazard symbol**	
	All correct	***78 %***
	Incorrect	22 %

Table 5: *summary of the 21-item CBRNe knowledge test, with questions condensed and % showing selection frequency for each option (n=419). Correct answers appear in bold italic.*

SELF-REPORTED KNOWLEDGE

Self-rated CBRNe knowledge was low (mean = 3.16/10, SD = 1.81), reflecting limited perceived competence in this domain (**Table 6**). A weak but statistically significant correlation with objective test performance was observed (Spearman's $\rho = 0.11$, $p = 0.024$), indicating that students' self-assessment only modestly tracked their actual knowledge. Self-reported knowledge did not differ meaningfully across training years, suggesting that students' perception of their own CBRNe preparedness remained consistently low throughout the curriculum.

WILLINGNESS TO ASSIST IN CBRNE INCIDENTS

Despite limited objective and self-perceived knowledge, students reported a high willingness to assist in CBRNe incidents (mean = 7.0/10, SD = 2.32) (table 5). Welch's ANOVA revealed significant differences in willingness across years ($p < .001$, $\omega^2 \approx 0.07$). Post hoc Bonferroni-adjusted comparisons showed that 3rd-year Master students were significantly more willing to assist than both 1st- and 2nd-year Master students ($p \leq 0.001$), while 2nd-year students reported lower willingness than 1st-year students ($p \leq 0.001$). Willingness correlated moderately with objective knowledge (Spearman's $\rho = 0.25$, $p < .001$) and weakly with self-reported knowledge ($\rho = 0.12$, $p = 0.018$), suggesting that knowledge contributes to, but does not fully determine, motivation to participate in CBRNe response.

Type of incident	**Self estimated knowledge** (0-10)	**Willingness to respond** (0-10)
Nuclear incidents	*2.6*	*7.0*
Chemical incidents	*2.6*	*7.6*
Biological incidents	*2.9*	*7.2*
Outbreak very infectious disease (e.g. H5N1)	*4.5*	*7.3*
Outbreak very dangerous contagious infection (e.g. Ebola)	*4.4*	*6.4*
Combined incidents (e.g. dirty bomb)	*1.9*	*6.9*
Overall average	***3.2***	***7.0***

Table 6*: Mean self-reported knowledge (0-10 scale; 0=no knowledge) and willingness to respond (0-10 scale; 0 = not at all) across CBRNe incident types.*

SUBGROUP ANALYSIS

Exploratory subgroup analyses examined whether prior experience, training, or environmental factors were associated with knowledge and willingness. Students with hospital-related experience or participation in CBRNe-specific training modules showed slightly higher objective knowledge scores (Cohen's d ≈ 0.25-0.45), indicating small to moderate gains associated with structured exposure. In contrast, more general experiences, such as non-specific clinical placements or general simulations, were not consistently linked to higher scores. Proximity to nuclear or chemical installations, as well as prior exposure to emergency medicine or disaster management activities, did not systematically correlate with higher knowledge or willingness scores. These findings suggest that targeted, structured CBRNe training is more effective in improving knowledge than general clinical exposure or merely living near hazardous sites.

SYNTHESIS

Taken together, these results show that medical students' objective CBRNe knowledge is limited and only weakly mirrored in their self-assessment, yet their willingness to participate in CBRNe incidents is high, particularly among more senior students. The positive, albeit moderate, association between knowledge and willingness indicates that improving competence may further strengthen motivation and preparedness, but other factors also shape students' readiness to help. The combination of high willingness and low knowledge highlights a critical educational gap: integrating structured CBRNe and disaster medicine training into the curriculum is needed to align students' motivation with adequate competence, thereby supporting safe and effective involvement in potential CBRNe emergencies.

DISCUSSION

Medical students at two major Belgian universities demonstrated limited objective knowledge of CBRNe incidents, achieving on average only about 55% of the maximum test score, while simultaneously reporting low self-perceived knowledge but high willingness to assist in emergencies. This pattern is consistent with multiple international studies in which healthcare trainees' perceived preparedness and willingness to respond to CBRNe or disaster scenarios exceeds their objectively measured knowledge and skills (Mortelmans et al., 2013, 2015; Rahman et al., 2024; Sheikhi et al., 2025). In a previous Belgian comparison of military versus civilian medical students, similarly low knowledge scores in the civilian group (mean 4.34/10) were observed alongside high willingness ratings (around 7/10), closely mirroring the current findings despite nearly a decade having passed (Mortelmans et al., 2016). The rather modest overall response rate (18.48%), partly driven by institutional barriers at other faculties, may overestimate true preparedness, as non-respondents could be less engaged; however, this rate is in line with response rates reported in earlier Belgian and Dutch work on disaster preparedness (Mortelmans et al., 2013, 2015).

The weak correlations between objective knowledge, self-rated competence, and willingness suggest that students' confidence and readiness to help arise more from general altruism, professional identity formation, and perceived duty than from CBRNe-specific training. In this context, the finding that willingness increases across training years while knowledge remains largely unchanged reinforces the notion that clinical socialisation, rather than curricular content, drives readiness to engage. At the same time, small positive associations between certain structured experiences (e.g. hospital-related exposure or CBRNe-focused training modules) and knowledge scores underscore the added value of targeted education, whereas more diffuse experiences or simple proximity to hazardous sites do not appear to systematically enhance preparedness[22].

These findings underscore the need for standardized, competency-based CBRNe curricula within medical education, echoing European reviews that highlight inconsistent coverage of disaster medicine and an overreliance on ad hoc or one-off simulation activities. Educational interventions such as scenario-based mastery learning, high-fidelity simulations, and interprofessional exercises have been shown in international studies to improve both knowledge and self-efficacy in disaster and CBRNe contexts, and therefore offer a feasible model for integration in the Belgian setting (Djalali et al., 2017; Malek et al., 2025; Rossodivita et al., 2023). Following the implementation of a dedicated elective or longitudinal course in incident management and CBRNe preparedness, the present questionnaire could be reused to evaluate changes in students' knowledge and willingness, allowing for longitudinal assessment of learning trajectories and optimisation of course scope and intensity.

LIMITATIONS

This study has several limitations. Its cross-sectional design precludes causal inferences about training effects on knowledge or willingness. Reliance on self-reported data for willingness, prior experiences, and demographics introduces potential recall and social desirability biases. Selection bias is evident from the modest response rate (18.5%) and participation limited to two faculties (KU Leuven, UAntwerpen), despite outreach to all Belgian programs. Institutional policies restricted broader distribution, possibly overrepresenting engaged students.

The 21-item knowledge test lacks independent external validation, such as formal reliability testing or established cutoffs for competence. However, items were adapted from validated instruments in prior Belgian/Dutch disaster medicine surveys, ensuring content validity grounded in peer-reviewed precedents.

Generalizability beyond master's students or to practicing physicians remains untested. No a priori power calculation was performed, risking underpowering subgroup analyses. Future work should employ longitudinal designs and psychometrically robust instruments.

CONCLUSION

This study identifies a critical discrepancy among Belgian medical students between high willingness to assist in CBRNe incidents and limited objective knowledge, with participants achieving only 54% on a standardized test despite reporting moderate self-perceptions of competence. Although certain clinical experiences appear to modestly improve preparedness, the absence of formal CBRNe training within medical curricula leaves future physicians insufficiently prepared for rare but high-impact scenarios. These results highlight an urgent need for scenario-based CBRNe education integrated into medical training programs, capitalizing on students' altruism to enhance both confidence and competence. Improving such preparedness is essential to strengthening the Belgian healthcare workforce's capacity to contribute to national resilience against chemical, biological, radiological, and nuclear threats. The planned elective course Incident Management at KU Leuven, developed following national consultation between Defence and academic institutions, represents a promising first step in bridging the preparedness gap identified in this study.

GENERAL CONCLUSION

The complementary findings from these two investigations delineate a nuanced landscape of CBRNe preparedness in Belgian healthcare. The hospital survey documents marked advancements since the 2014 baseline, including near-universal integration of CBRNe scenarios in disaster plans (90%), expanded decontamination facilities (76%, with university centers achieving significantly higher decontamination rate: $p < 0.001$), and improved antidote/PPE stockpiles (e.g., atropine 100%, class 3-4 PPE > 96%). Nonetheless, disparities persist, regional hospitals lag in capacity and training (only 42% report adequate decontamination staff), exacerbated by absent dedicated funding (0%), underscoring uneven resilience.

Parallel assessment among 419 master's medical students reveals profound knowledge deficits (mean 12.1/22 or 55% correct), spanning decontamination (45% correct), radiation triage (variable < 89%), and recognition (e.g., anthrax 45%), uncorrelated with study year ($p = 0.082$). Strikingly, this coexists with robust altruism (willingness 7/10 across scenarios), weakly linked to knowledge ($\rho = 0.25$), signaling untapped potential hampered by curricular neglect.

Integrated, these results advocate a stratified national strategy: fortifying tiered hospital networks while embedding competency-based CBRNe education to align motivation with capability, thereby elevating Belgium's health security amid industrial/geopolitical vulnerabilities.

Future research should prioritize prospective validation via multisite simulation exercises assessing operational performance beyond self-reports, longitudinal tracking of curricular interventions' impact on student competence, and comparative analyses with EU peers (e.g., Germany/France) to refine tiered models.

LIST OF ABBREVIATIONS

ANOVA: Analysis of Variance

AZ Delta: AZ Delta (hospital in Roeselare, Belgium)

BeMSA: Belgian Medical Students Association

CBRN(e): Chemical, Biological, Radiological, Nuclear(, and Explosive)

DM: Disaster Medicine

EM: Emergency Medicine

KU Leuven: Catholic University of Leuven

LimeSurvey: LimeSurvey (online survey platform)

Likert: Likert scale (self-rating from 0-10)

MCQ(s): Multiple-Choice Question(s)

NY: New York (SPSS publisher location)

PPE: Personal Protective Equipment

Q-Q: Quantile-Quantile (plots)

QR: Quick Response (code)

SD: Standard Deviation

Seveso: Seveso-class (industrial facilities directive)

SPSS: Statistical Package for the Social Sciences (version 30.0, IBM Corp., Armonk, NY, USA)

UAntwerpen: University of Antwerp

UGent: Ghent University

ULB: Université Libre de Bruxelles

ULiège: University of Liège

VUB: Vrije Universiteit Brussel

ZAS Cadix: ZAS Cadix (hospital in Antwerp, Belgium)

ρ (rho): Spearman's rank correlation coefficient

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SUPPLEMENTAL MATERIALS

(A) FULL QUESTIONNAIRE LIST HOSPITAL SURVEY

General information

1. What is your professional position?
    a) Head of the Emergency Department
    b) Emergency Department Staff Member
    c) Hospital Emergency Plan Coordinator
    d) Other, please specify…

2. What is the name of your hospital?

3. How would you describe the size/type of your hospital?
    a) University
    b) Supra-regional
    c) Regional

4. In which province is your hospital located?
    a) Limburg
    b) Flemish Brabant
    c) Antwerp
    d) East Flanders
    e) West Flanders
    f) Hainaut
    g) Walloon Brabant
    h) Namur
    i) Liège
    j) Luxembourg
    k) BCR (Brussels-Capital Region)

Questionnaire on CBRNe Preparedness

1. CBRNe incident risk
    a) Is there a chemical risk factor (Seveso type) in the sector you serve?
    b) Is there a nuclear installation in the sector you serve?
    c) Are there other risks in your sector (e.g. terrorism target)?

2. Hospital disaster plan
    a) Does the emergency department (ED) participate in the hospital disaster plan?
    b) Is there some CBRN(e) scenario included in the plan? Are there any regulations for:
    c) Mobilization of extra personnel?
    d) Mobilization of extra staff with specific expertise/training in CBRN?
    e) Mobilization of extra supplies?
    f) Creation of extra bed capacity?

3. Decontamination
   a) Do you have any decontamination facilities?
   b) Are they permanently available or deployable on demand?
   c) Are they in front of/at the entrance or somewhere inside the boundaries of the ED?
   d) What is your decontamination capacity for walking and supine patients?
   e) Is there isolated waste treatment?
   f) Is your staff trained to use them?
   g) Are there any security personnel to control it?

4. Personal protective equipment (PPE)
   a) Do you have PPEs at your disposal? Specify class and number:
      a. 1: Full body containing chemical suit with self-contained breathing apparatus (SCBA)
      b. 2: Chemical splash suit, canister, air purifier, face mask
      c. 3: Gloves, gown, goggles, and N95 respirator mask
      d. 4: Gloves, gown, goggles, and surgical mask
   b) Is your staff trained to use them?

5. Antidotes
Do you have these antidotes at your disposal? Please specify the amount.
   a) Atropine
   b) Pralidoxime/obidoxime
   c) Ethanol
   d) Flumazenil
   e) Naloxone
   f) N-acetylcysteine
   g) Hydroxycobolamine
   h) Thiosulphate
   i) Glucagon
   j) Calcium gluconate

6. Radiation/nuclear threats
   a) Is there a department of nuclear medicine in your hospital?
   b) Are there any arrangements to have a nuclear medicine specialist permanently on staff 24/7 in case of radiation/nuclear incidents?
   c) Do you have any radiation detection probes equipped with an alarm function at your disposal?
   d) Which type of radiation is measured?
   e) What is the number?

7. Biological threats

a) Are there any arrangements to have infectiologists/microbiologists permanently on staff 24/7 to help victims suspected of being contaminated with biological agents (e.g. anthrax, smallpox, etc.)?
b) Do you have any facilities for medical isolation in the ED?
    a. Individual
    b. Collective

8. Financial support

Does your hospital receive any financial support aimed at enhancing its CBRNe preparedness? If so, please provide details.

(B) FULL QUESTIONNAIRE LIST STUDENT SURVEY

General Information

1. What is your age?

2. Which year of medical school are you in?
   a) 1st year of Master's in Medicine
   b) 2nd year of Master's in Medicine
   c) 3rd year of Master's in Medicine

3. Through which university are you completing your studies?
   a) UGent
   b) KULeuven
   c) UAntwerpen
   d) VUB
   e) University of Namur
   f) ULiège
   g) ULB
   h) UCLouvain

4. Which medical specialties are you (potentially) interested in? (Multiple answers possible)
   a) General Practice
   b) Specialization
      a. Emergency Medicine
      b. Anesthesiology
      c. Intensive Care Medicine
      d. Nuclear Medicine
      e. Infectious Diseases
   c) Other

5. Are you completing your medical training through the military?
   a) Yes
   b) No

Knowledge and experience

1. Outside your medical studies, do you have contact with emergency medicine / disaster medicine?
   a) First Aid provider
   b) Ambulance Service
   c) Fire Department
   d) Military
   e) Other

2. Have you previously had training in disaster medicine?
   a) Yes – via university
   b) Yes – through other means
   c) No

3. Do you have any knowledge about handling chemical/nuclear/biological incidents and treating the victims?

a) Yes – via university
b) Yes – via another course
c) Yes – via the internet
d) Yes – via literature
e) Yes – other
f) No

4. Do you think a basic course in disaster medicine should be added to medical training?
a) Absolutely necessary
b) Could be useful
c) Useless

5. Do you live within a 20 km radius of a nuclear facility?
a) Yes
b) No
c) I don't know

6. Do you live within a 20 km radius of a chemical (Seveso) facility?
a) Yes
b) No
c) I don't know

7. How would you rate your own knowledge on a scale from 0–10? (0 = no knowledge, 10 = fully knowledgeable)
a) Nuclear or radiological incidents: 0–10
b) Chemical incidents: 0–10
c) Biological incidents (e.g., anthrax): 0–10
d) Epidemiological outbreak of a highly contagious disease (e.g., avian flu): 0–10
e) Epidemiological outbreak of a highly dangerous and contagious disease (e.g., Ebola): 0–10
f) Combined incidents (e.g., dirty bomb, explosive with chemical/nuclear/biological hazard): 0–10

8. If you were confronted with any of the following scenarios in the future, would you participate in the care of these patients? (0 = not at all, 10 = absolutely yes)
a) Nuclear or radiological incidents: 0–10
b) Chemical incidents: 0–10
c) Biological incidents (e.g., anthrax): 0–10
d) Epidemiological outbreak of a highly contagious disease (e.g., avian flu): 0–10
e) Epidemiological outbreak of a highly dangerous and contagious disease (e.g., Ebola): 0–10
f) Combined incidents (e.g., dirty bomb, explosive with chemical/nuclear/biological hazard): 0–10

Knowledge test

1. During your clinical rotation, a mass casualty incident occurs. There is a collision involving multiple cars, trucks, and a bus. You are asked to take charge of triaging the victims at the emergency entrance. Four people with minimal or no injuries, wearing wet clothes and emitting an irritating odor, arrive. What do you do?
    a) Place them in a remote corner of the emergency department so their odor does not bother other patients.
    b) Place them in the waiting area and focus on the seriously injured patients.
    c) Have them wait in the garage behind triage so the odor is contained.
    d) Place them at the entrance and call your supervisor.
    e) Do nothing and hide somewhere in the hospital.

2. The government provides free iodine tablets to be used in case of a nuclear incident. What do they protect against?
    a) External radiation
    b) Internal radiation
    c) External and internal radiation
    d) Do not protect against radiation
    e) I don’t know

3. In the emergency department, you see a postman with a small black necrotic wound on his hand. What is the cause?
    a) Frostbite due to a cold winter
    b) Use of a new aggressive chemical agent while handling mail
    c) Possible malicious spread of anthrax via mail
    d) Use of a new type of black ink
    e) I don’t know

4. How do you decontaminate a patient after a chemical incident?
    a) Oral antidote
    b) Apply a specific antidote ointment on the body
    c) Use a special military cabin to spray a specific antidote over the whole body
    d) Wash/shower with water and soap
    e) I don’t know

5. How do you best limit radiation damage?
    a) Use of PPE (personal protective equipment)
    b) Rapid decontamination
    c) Oral iodine tablets
    d) Limit exposure time, shield, and maintain maximum distance from the source
    e) I don’t know

6. During a vacation, you and your friends are evacuated from a hotel due to flooding. What are the two most important items to bring?
    a) Smartphone
    b) Laptop
    c) ID card or insurance card
    d) Drinks and food
    e) Your medication or a list of medications
    f) A photo of a loved one

g) None of the above
h) I don’t know

7. During a student party, an explosion occurs in the hall with multiple deaths and severely injured victims. Fortunately, you were outside at the time and are unharmed. Three friends have superficial glass wounds and first-degree burns on their arms. You can transport them in your own car. Where do you go?
a) The nearest hospital so everyone stays together
b) The nearest burn center
c) Your own home to recover from the emotions
d) A more distant emergency department
e) I don’t know

8. What is the first step in decontaminating a patient after a nuclear incident?
a) Shower
b) Oral iodine tablet
c) Remove clothing and shoes
d) Give the patient a lead apron to wear
e) I don’t know

9. On the way to the hospital, you pass an accident with two trucks. From the first tanker, an unknown liquid sprays under high pressure. A patient lies unconscious near this truck but is still moving slightly. The driver of the other truck is limping and trying to get your attention. What do you do?
a) Stop, call 112, and check the patient on the ground.
b) Stop, call 112, check the limping patient first, then check the patient on the ground.
c) Stop at a safe distance and wait for firefighters to declare it safe to approach.
d) Drive on and call 112 as soon as possible.
e) Drive on as if nothing happened.

10. Secondary contamination with chemical substances is mentioned. What does this mean?
a) Initially contaminated persons or objects are touched.
b) Contact with hazardous substances settled on materials.
c) Eating or drinking contaminated food or beverages.
d) Inhalation of exhaled air from victims.
e) All of the above are correct.
f) None of the above are correct.
g) I don’t know

11. Which physical state of a chemical substance can lead to the highest absorption through the skin?
a) Solid
b) Liquid
c) Gas
d) I don’t know

12. True or false? In an incident with radiological or nuclear material, everyone exposed to radiation will also be contaminated.
a) True
b) False

c) I don’t know

13. Prophylaxis of Anthrax after exposure is based on the administration of:
a) Antidote
b) Antibiotic
c) Antiviral medication
d) Antifungal medication
e) I don’t know

14. Which type of radiation is the most difficult to detect in a patient contaminated with radiological or nuclear material?
a) Alpha radiation
b) Beta radiation
c) Gamma radiation
d) I don’t know

15. What is the primary route for internal contamination in a radiological or nuclear incident?
a) Inhalation
b) Absorption through the skin
c) Ingestion
d) I don’t know

16. For which chemical agents is rapid treatment with oxygen important?
a) Corrosive agents
b) Blister agents
c) Blood agents
d) I don’t know

17. Atropine is the antidote for …?
a) Nerve agents
b) Choking agents
c) Vesicant agents
d) All of the above
e) I don’t know

18. Which of the following substances cause chemical burns in the airways? (Multiple answers possible)
a) Sulfuric acid
b) Sarin (nerve gas)
c) Cyanide
d) Gasoline
e) Bases
f) I don’t know

19. True or false? Iodine must be ingested by every person in Belgium in the event of a nuclear incident.
a) True
b) False
c) I don’t know

20. True or false? If a visible solid substance is on a patient's skin, I will always rinse it with water, which cannot be harmful.

a) True
b) False
c) I don't know

21. Match the correct name with the correct symbol:

a) Radiological material
b) Flammable
c) Environmental hazard
d) Gases under pressure
e) Biological hazard
f) Explosive
g) Corrosive
h) Toxic

