

Brief Report

Cite this article: Hupf J, Zimmermann M, Maier-Stocker C, Hanses F, Mortelmans LJM and Halpern P (2024). Evaluation of CBRN Preparedness of German Hospitals with Higher Level of Care: A Cross-Sectional Survey. *Disaster Medicine and Public Health Preparedness*, **18**, e133, 1–4
<https://doi.org/10.1017/dmp.2024.130>

Received: 06 September 2023

Revised: 15 May 2024

Accepted: 23 May 2024

Keywords:



mass casualty incidents; chemical terrorism; disaster planning

Corresponding author:

Julian Hupf;

Email: Julian.Hupf@ukr.de

Evaluation of CBRN Preparedness of German Hospitals with Higher Level of Care: A Cross-Sectional Survey

Julian Hupf¹ , Markus Zimmermann¹, Constantin Maier-Stocker¹, Frank Hanses¹, Luc J.M. Mortelmans²  and Pinchas Halpern³

¹Emergency Department, University Hospital Regensburg, Regensburg, Germany; ²Department of Emergency Medicine, ZNA Camp Stuivenberg, Antwerp, Belgium and Center for Research and Education in Emergency Care (CREEC), University Leuven, Belgium and ³Assoc. Professor (Emeritus) of Emergency Medicine, Anesthesiology, and Critical Care. Retired Chair, division of Emergency Medicine, Tel Aviv University and Tel Aviv Medical Center

Abstract

Objective: Chemical, biological, radiological, and nuclear (CBRN) events with multiple casualties are rare events, but preparedness is crucial for hospitals to respond properly. This study evaluated the preparedness and disaster planning of German hospitals for CBRN incidents.

Methods: In a cross-sectional study, German hospitals with level III (highest level) emergency departments were surveyed using an online questionnaire focusing on risk assessment, infrastructure, hospital disaster planning, and preparedness for CBRN events.

Results: Between June and July 2023, 50 hospitals were surveyed. 62.5% of the hospitals had a section on chemical incidents in their disaster plan. A decontamination facility was available in 29.8% of the hospitals and chemical protective suits in 46.8%. The minority of the hospitals trained the correct handling of personal protective equipment (PPE) (39.1%) regularly or had frequent CBRN drills (21.3%). Most hospitals had the infrastructure for medical isolation (93.6%).

Conclusions: The level of CBRN preparedness is heterogeneous for German hospitals. Most were well prepared for infectious patients, but only half of all hospitals had sufficient PPE for chemical incidents and only 30% had a decontamination facility available. Overall, the level of CBRN preparedness is still insufficient and needs further improvement.

Chemical, biological, radiological, and nuclear (CBRN) incidents with multiple affected individuals are rather rare events in Europe and are mainly due to industrial accidents.¹ Recently, sporadic chemical weapons incidents, the Russian-Ukrainian war, and the COVID-19 pandemic wave have raised awareness of CBRN preparedness and risk reduction/mitigation in the European Union (e.g., EU CBRN Centres of Excellence).

As known from previous incidents,² particularly in the case of terrorist attacks, large numbers of contaminated patients may arrive on their own and pose a continuing threat to staff and others. Therefore, hospitals should have internal guidelines for setting up decontamination facilities and specific treatment of casualties in case of a CBRN incident. This requires special equipment (decontamination, personal protective equipment, antidote stocks), guidelines, and, foremost, structured training of the staff.

Due to the federal structure of Germany, there are no uniform regulations on emergency preparedness for mass casualty or CBRN incidents. As each federal state has its own statutory regulations for hospital disaster planning, there is no standardized or mandatory structure for hospital disaster plans in Germany. Furthermore, there are no control instances to ensure that hospitals comply with the regulations. In addition, only a few states have implemented programs and guidelines for hospitals and emergency services to prepare specifically for CBRN events. Therefore, the overall level of hospital preparedness for CBRN incidents is expected to be limited.³

This study aims to provide insight into the potential response capacities of German hospitals with emergency departments of the highest level (Federal Joint Committee level 3) and their influencing factors in the event of a CBRN incident in a standardized manner.

Methods

For this cross-sectional descriptive study, an online survey was developed using a previously validated questionnaire^{4,5} and a proposed hospital assessment tool for CBRN preparedness.⁶ The questionnaire was translated into German and validated with senior emergency physicians not involved in the survey.

© The Author(s), 2024. Published by Cambridge University Press on behalf of Society for Disaster Medicine and Public Health, Inc. This is an Open Access article, distributed under the terms of the Creative Commons Attribution licence (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted re-use, distribution and reproduction, provided the original article is properly cited.

Hospitals with a level 3 emergency department (according to the criteria of the German Federal Joint Committee “G-BA”) were eligible to participate in the survey, with level 3 representing the highest level. A list of level 3 emergency departments was compiled using data from the German Association of Statutory Health Insurance Funds. For each hospital, the head of the emergency department was contacted to participate in the survey with a personalized code to avoid duplicates. The initial invitation was sent by letter, and nonresponders were reminded to participate by email 3 weeks later.

SPSS (IBM Corp. Released 2021. IBM SPSS Statistics for Windows, Version 28.0) was used to analyse the data. Categorical data was analyzed using the χ^2 test, and a *p* value of less than 0.05 was considered as significant.

To estimate the nonresponse bias, the survey data were categorized as early or late, with late being defined as data provided by respondents who completed the survey after the reminder email. A significant difference between early and late data indicated a potential nonresponse bias for that question.

The study was reviewed and exempted from full review by the local ethics committee of the University Medical Center Regensburg (AZ 23-3389-101).

Results

Baseline Characteristics

The survey was conducted between June and July 2023. At the time of the study, 165 eligible hospitals with a level 3 emergency department were identified, and in 153 cases, a department head could be identified and contacted. The response rate was 30.3% (*n* = 50 from 165).

Most of the participating hospitals (81.6%) were tertiary care facilities and of larger size (79.6%) with more than 500 beds (Table S1, online data supplement). There was no statistically significant difference in the distribution of federal states of eligible and responding hospitals (*p* > 0.05).

Risk Assessment and Hospital Disaster Planning

Most of the hospitals (77.6%) (Table S2) had a facility with the risk of a chemical accident in their vicinity. In contrast, only 33.3% of the hospitals were located near a nuclear facility and 51% of hospitals described other CBRN risks of which they are aware. Only a few hospitals (4.3%) conducted hazard vulnerability analyses for sources of hazardous material in the vicinity.

The emergency department was involved in hospital disaster planning in 85.7% of the cases. Most hospitals had a section in their disaster plan about mobilization of additional staff (97.9%) (Table S3). To facilitate staff activation in the event of a disaster, 87.5% of the hospitals were reported to have standard operating procedures (SOPs) (e.g., telephone cascade) or technical infrastructure (e.g., automated phone system, messaging system, smartphone app). Most hospitals also had sections on mobilization of extra bed capacity (68.8%), supplies (77.1%), and pharmaceuticals (72.9%) in case of a disaster.

62.5% of the hospitals stated that they have disaster drills, but only 35.4% had a drill in the last year. Most drills were realistic simulations (86.7%), less often tabletop exercises (20.0%) or paper simulations (24.4%).

CBRN Preparedness

The hospital disaster plan of the participating hospitals included a section on chemical incidents in 62.5%, on nuclear incidents in

39.6%, and on major incidents with contagious/infected patients in 87.5% of the cases (Table S3). In contrast, only 29.2% of all respondents had a section on the mobilization of personnel with specific CBRN training/knowledge in their disaster plan.

In terms of personal protective equipment (PPE), 50.0% (Table S4) of the health-care facilities surveyed had high-level respiratory protection (air-purifying respirators, suits with an integrated powered air-purifying respirator, or self-contained breathing apparatus) and 46.8% had chemical protective suits. The number of chemical protective suits available was variable: 31.8% (*n* = 7) had less than 6, 36.4% (*n* = 8) had 6-10, and 27.3% (*n* = 6) had more than 10 chemical protective suits. Overall, the majority of hospitals had less than or equal to 10 suits available. There was no statistically significant relationship between the number of chemical protective suits in stock and the size of the hospital (in number of beds) or the ED (in patients per year). A minority of the hospitals were reported to regularly train the correct handling of PPE (39.1%) or have CBRN drills (21.3%). Further, 25.5% of the hospitals had a training program for use of PPE and decontamination procedures.

29.8% of the responding institutions were stated to have a decontamination facility (Table S5); 50% of those were permanent installations and most (85.7%) were located in front of or at the entrance to the emergency department. Further, 37.0% of all respondents had a SOP for patient decontamination.

Specific triage algorithms or treatment guidelines for CBRN incidents were only available in 17% and 19.1%, respectively, of the responding hospitals.

Most of the hospitals had the infrastructure for medical isolation in their emergency department (93.6%). In addition, most hospitals (83%) had arrangements with infectiologists and/or microbiologists for advice on potential biological incidents.

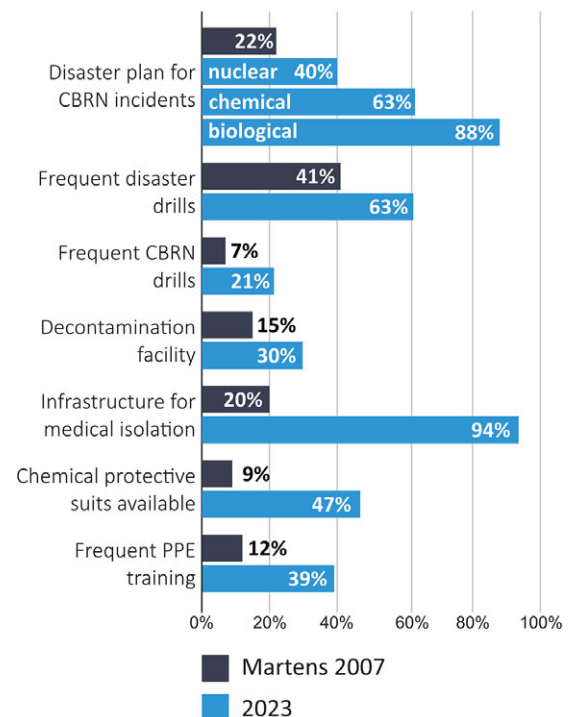


Figure 1. Comparison between the results of this study and the survey of Martens in 2007 regarding CBRN preparedness of German hospitals.

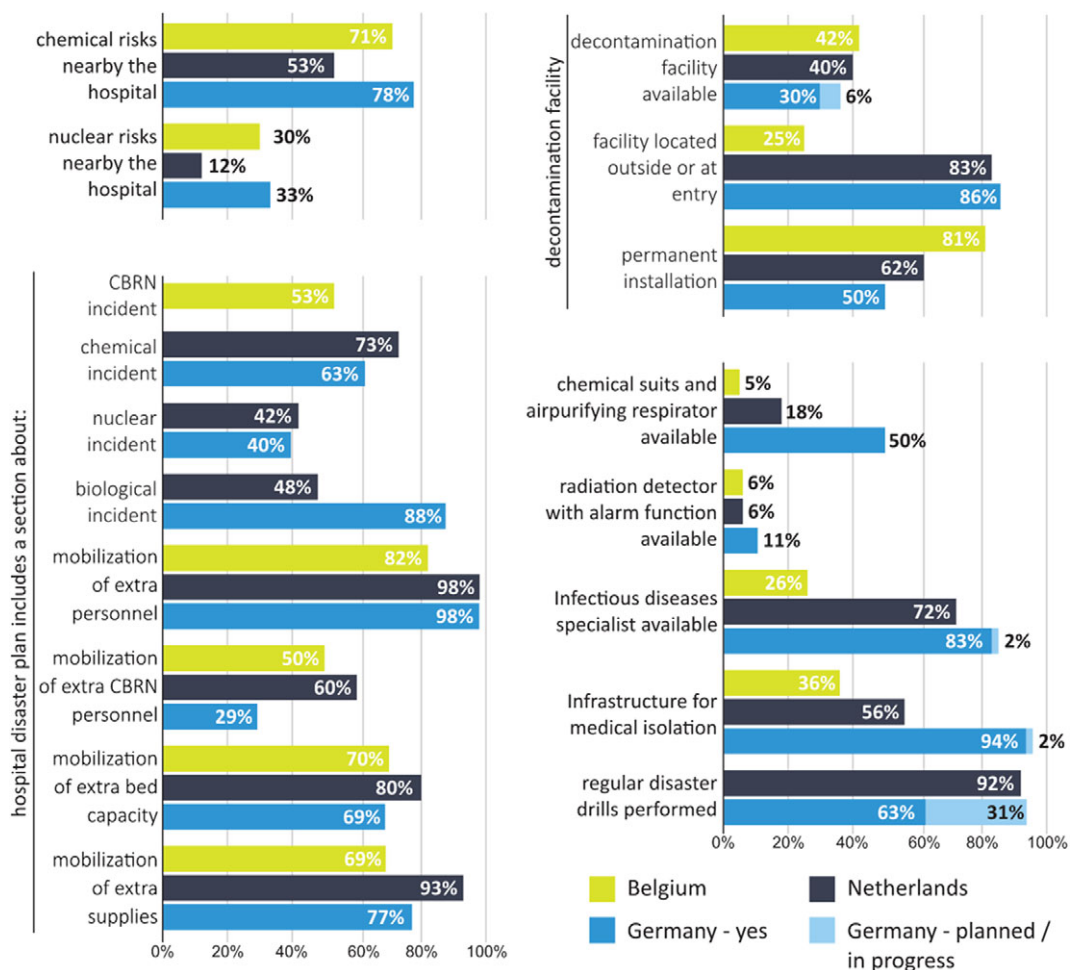


Figure 2. CBRN preparedness of German, Belgian and Dutch hospitals.

Equipment and Antidotes

Most hospitals had antidotes for intoxications with common chemical substances or drugs available, although the amount of treatment doses varied (Table S4). In contrast, chelating agents for radionuclide poisoning, like DTPA or Prussian blue, were available in only 71.8% and 59% of the hospitals surveyed, respectively. Similarly, pralidoxime or obidoxime as a specific antidote for organophosphate poisoning was only available in 70.8% of the facilities. Only 29% of the emergency departments had more than 5 treatment doses of oximes in stock.

In preparation for a nuclear incident, only 14.9% of the hospitals reported having a radiation detector and most of these are equipped with an alarm function (71.4%).

For 5 of 64 questions (Tables S2, S3, and S5), there was a significant difference ($p < 0.05$) between early and late respondents, indicating potential nonresponse bias for these questions.

Longitudinal and European Comparison

Compared to data from a previous study on the CBRN preparedness of German hospitals in 2007³ (Figure 1), there was a substantial increase in CBRN preparedness in all categories, such as hospital disaster planning, regular trainings/drills, or availability of

chemical protective suits. Most remarkably, in contrast to the results from 2007 (20%), virtually all hospitals in this study had infrastructure for medical isolation (94%).

Furthermore, compared to 2 more recent studies on Belgian and Dutch hospitals,^{4,5} the chemical risks in the vicinity to the hospitals and hospital disaster planning were comparable to those of German hospitals (Figure 2). However, Dutch and Belgian hospitals were more likely to have a decontamination facility available (42% and 40%) than German hospitals (30%). German hospitals had a higher availability of high-level PPE and infrastructure for medical isolation.

Limitations

This survey has a high potential for a variety of biases. The response rate was 30.3%, which is relatively low and increases the risk of nonresponse bias.⁷ There was a significant difference in results between early and late respondents in only 5 of 64 questions, which could indicate a nonresponse bias. Furthermore, only hospitals with a level III ED were invited to participate, as they are most likely to be responsible for responding to CBRN incidents. Therefore, the results are not comparable to the total population of German emergency departments.

Discussion

CBRN Preparedness of German Hospitals

This study assessed the disaster planning and preparedness of German hospitals with level 3 (highest level) emergency departments for CBRN events and, for the first time, compared the results with longitudinal data and survey results from other European countries. While there are over 1000 emergency departments in Germany, only 165 are level 3 (maximum level) EDs with extended responsibilities, such as CBRN incidents. Therefore, this study focused on these facilities.

CBRN events are comparatively rare events in Germany. In a previous survey, only 4% of the hospitals included had reported about CBRN incidents in the past.³ The combination of the low incidence of CBRN events, the high costs of CBRN preparedness, and the lack of federal regulations or support undermine a widespread and high level of preparedness.

Overall, the level of preparedness was heterogeneous. While almost all hospitals were well prepared for infectious patients, most likely as a result of the COVID-19 pandemic, many facilities have inadequate equipment and structural deficiencies to deal with chemical, radiological, or nuclear incidents.

Longitudinal Comparison

In a study by Martens in 2007³, German hospitals were surveyed on CBRN preparedness. The study addressed all hospitals with an emergency department; a total of 852 hospitals were asked to participate. The majority of the responding hospitals were of smaller size with basic care facilities. As this study clearly focused on advanced and maximum care facilities, the results should be compared with caution. Compared to the results of Martens, there is a substantial increase in CBRN preparedness (Figure 1) in all categories. In terms of PPE and medical isolation, this is most likely a consequence of the SARS-CoV-2 pandemic.

CBRN Preparedness of European Hospitals

In 2 studies, Mortelmans et al.^{4,5} found that only a minority of the Dutch and Belgian emergency departments were prepared to deal with a CBRN incident (Figure 2). The chemical risks in the vicinity to the hospitals and hospital disaster planning were comparable to the results of this study. Dutch and Belgian hospitals had a decontamination facility available more often than German hospitals and had more often in their disaster plan a section on mobilization of staff with special CBRN training. On the other hand, German hospitals were more likely to have high-level PPE, infrastructure for medical isolation, and disaster planning for biological incidents/contagious patients. This is most likely an effect of the COVID-19 pandemic. During the pandemic, many hospitals acquired or were supplied with suits with integrated powered air-purifying respirators (“blower-suits”), so a higher availability of high-level PPE is not surprising. While this study focused on hospitals with an ED of the highest level, the Dutch and Belgian hospitals in the study of Mortelmans were of all levels.

In 2 very recent surveys on counterterrorism preparedness^{8,9} of Dutch and Flemish hospitals, even more EDs (84% and 61%) had a decontamination unit available. Furthermore, 49% of the Flemish hospitals had sufficient PPE available to deal with a CBRN incident.

This is significantly more than before³ and comparable to German hospitals.

Conclusion

This study assessed the CBRN preparedness of German emergency departments at the highest level and found a heterogeneous level of preparedness. Most hospitals were well prepared for infectious/contagious patients, which is clearly an effect of the COVID-19 pandemic. In contrast, only half of all hospitals had sufficient PPE for chemical incidents and only 30% had a decontamination facility available. While 63% of the hospitals had regular disaster drills, only 21% had CBRN drills. In comparison to Belgium and the Netherlands, German hospitals were less likely to have a decontamination unit or specialized CBRN staff. Overall, the level of CBRN preparedness is still insufficient and needs further improvement. Based on the results of this study, federal states should harmonize the regulations and provide funding, legal requirements, coordination, and structural guidance for hospital disaster planning, in general and for CBRN incidents.

Supplementary material. The supplementary material for this article can be found at <http://doi.org/10.1017/dmp.2024.130>.

Acknowledgments. This work is the result of a thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Disaster Medicine (European Master Disaster Medicine).

Author contribution. JH: study conceptualization and design, methodology, data acquisition and analysis, writing (original draft, review and editing); MZ: study conceptualization and design, writing (review and editing); CMS: study conceptualization and design, writing (review and editing); FH: study conceptualization and design, writing (review and editing); LM: study conceptualization and design, writing (review and editing); PH: study conceptualization and design, methodology, data interpretation, supervision, writing (review and editing).

Competing interest. The authors declare none.

References

1. eMARS Database. Available at <https://emars.jrc.europa.eu/EN/emars/content>, accessed 06 September 2023.
2. Okumura T, Takasu N, Ishimatsu S, et al. Report on 640 victims of the Tokyo subway sarin attack. *Ann Emerg Med.* 1996;**28**(2):129–135.
3. Martens F. *Dekontamination von Verletzten im Krankenhaus bei ABC-Gefahrenlagen*. Bonn: Bundesamt für Bevölkerungsschutz und Katastrophenhilfe; 2009. Forschung im Bevölkerungsschutz; Bd. 9.
4. Mortelmans LJM, van Boxstael S, Cauwer HG de, et al. Preparedness of Belgian civil hospitals for chemical, biological, radiation, and nuclear incidents: are we there yet? *Eur J Emerg Med.* 2014;**21**(4):296–300.
5. Mortelmans LJM, Gaakeer MI, Dieltiens G, et al. Are Dutch hospitals prepared for chemical, biological, or radionuclear incidents? A survey study. *Prehosp Disaster Med.* 2017;**32**(5):483–491.
6. Olivieri C, Ingrassia PL, Della Corte F, et al. Hospital preparedness and response in CBRN emergencies: TIER assessment tool. *Eur J Emerg Med.* 2017;**24**(5):366–370.
7. Burkell J. The dilemma of survey nonresponse. *Libr Inf Sci Res.* 2003;**25**(3):239–263.
8. Barten DG, Janssen M, Cauwer H de, et al. Threat awareness and counterterrorism preparedness of Dutch hospitals: a cross-sectional survey. *Int J Disaster Risk Reduction.* 2024;**102**:104311.
9. Mortelmans L, Cauwer H, Barten D, et al. Counterterrorism preparedness of Flemish hospitals, a cross-sectional descriptive study. *European Emergency Medicine Congress.* 2023.