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Applying Human Factors methods to explore 'Work as Imagined' and 'Work as Done' in the Emergency Departments response to Chemical, Biological, Radiological, and Nuclear events

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Abstract.

The Emergency Department (ED) is a complex, hectic, and high-pressured environment. Chemical, Biological, Radiological, and Nuclear (CBRN) events are multi-faceted emergencies and present numerous challenges to ED staff (first receivers) with large scale trauma, consequently requiring a combination of complex responses.

Human Factors and Ergonomics (HF/E) methods such as Hierarchical Task Analysis (HTA) have been used in healthcare research. However, HF/E methods and theory have not been combined to understand how the ED responds to CBRN events.

This study aimed to compare Work as Imagined (WAI) and Work as Done (WAD) in the ED CBRN response in a UK based hospital. WAI was established by carrying out document analyses on a CBRN plan and WAD by exploring first receivers response to CBRN scenario cards. The responses were converted to HTAs and compared.

The WAI HTAs showed 4-8 phases of general organizational responsibilities during a CBRN event. WAD HTAs placed emphasis on diagnosing and treating presenting conditions. A comparison of WAI and WAD HTAs highlighted common actions and tasks. This study has identified three key differences between WAI and WAD in the ED CBRN response: 1) documentation of the CBRN event 2) treating the patient and 3) diagnosing the presenting complaint.

Findings from this study provide an evidence base which can be used to inform future clinical policy and practice in providing safe and high quality care during CBRN events in the ED.

Keywords: Human Factors and Ergonomics, CBRN events, Emergency Department

1 Introduction

A CBRN event is “the exposure (or risk of exposure) of a large number of individuals to hazardous Chemical, Biological, Radiological (and Nuclear) materials” [1]. The UK the Civil Contingencies Act (2004) places statutory duties on category one organizations’ such as Emergency Departments (ED) to plan, prepare, and respond to CBRN events effectively [2].

CBRN events present multifaceted demands on the ED [3, 4] which is already a complex, hectic, high-pressured, and often short-staffed environment [5, 6]. CBRN events are rare [7] resulting in first receivers being unfamiliar with the clinical assessment, containment, and treatment unique to patients who have been exposed to CBRN materials. This means that plans are used as a reference point and are implemented into policy and procedures to respond to CBRN events. Additionally, it is legislative practice in the UK to have well-practiced emergency plans [8].

Human Factors and Ergonomics (HF/E) “is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system” [9]. The use of HF/E is advocated as a means of improving healthcare quality and safety [10].

Hierarchical Task Analysis (HTA) is a central method of analysis in HF/E. HTA describes a task as a higher level goal with a hierarchy of superordinate and subordinate tasks. At each level of the subtasks, a plan directs the sequence and possible variance of task steps [11].

Responding to a CBRN event involves clinical work, based on guidelines and policies which represent Work as Imagined (WAI). This is what designers, managers, regulators, and authorities believe happens, or should happen in the workplace. Compliance to policies and guidelines suggests that Work as Done (WAD), what actually happens in the workplace, are similar or identical [12, 13].

This study combined the HF/E method (HTA) and theory (WAI vs. WAD) to better understand the ED response to CBRN events.

2 Method

2.1 Design

An exploratory qualitative design was used to ensure a data driven understanding of CBRN plans, with a continuous and thorough method of representation (HTA). Qualitative methods have been suggested to be effective to find out why people make choices and carry out tasks in certain ways in healthcare [14].

2.2 Pilot study

A publically available CBRN plan was downloaded from the Internet, and analyzed as an HTA as a pilot exercise to prepare for data collection and trial of various software for HTAs (e.g. Human Factors Risk Manager, Microsoft PowerPoint, and Microsoft

Visio). Microsoft Visio was predominantly used, because it provided the flexibility of gradually building up the HTA and an easy flow of the HTA over numerous pages. The scenario cards were piloted on three participants 1) SR (Emergency Department Practitioner), 2) an ex ED nurse, and 3) a first receiver in the ED.

2.3 Work as Imagined

WAI was established from a document analysis of a CBRN plan from a NHS hospital Trust in the UK. The Trust employs 15,000 staff; serves 1 million residents and treated 237,000 ED patients during 2016-2017. Document analysis was used as it requires data to be thoroughly examined and interpreted to elicit meaning, understanding, and develop empirical knowledge [15, 16]. The HTA was produced using Stanton [17] HTA guidance which encourages iterative verification of the analysis with subject matter experts.

2.4 Work as Done

During the WAD stage, CBRN based scenario cards representing chemical (Sarin), Biological (Severe Acute Respiratory Syndrome), and Radiological (Acute Radiation Syndrome) situations were presented to 29 first receivers. Scenario cards were used to create a hypothetical CBRN situation, scenario cards have effectively been used whilst testing incident command systems in hospital based disaster simulation exercises [18].

The inclusion criteria ensured that participants were 18 years and over, and had been employed in the ED for a minimum of three months on a substantial contract; this was to ensure that all participants had the opportunity to attend an induction training. This resulted in a sample of 15 females and 14 males, aged 21-60 years. The length of employment in the ED ranged from 5 months to 17 years. Purposive sampling was used to identify and select individuals knowledgeable about or experienced with a phenomenon [19].

Scenario cards were presented during a range of shifts. First receivers were given time to read the scenario card, and then asked to talk through their actions in response to the scenario. Field notes were used to record the data and converted to HTAs.

Stratified purposive was used to validate the findings from the scenario card presentations with subsequent interviews to compare, contrast, and identify similarities and differences in the phenomenon of interest [20]. The validation interview began by giving the first receiver the scenario card as a memory aid. The HTA was explained and the participants were asked “do you think this diagram is a true representation of what you would do in a CBRN event?” They were then given the opportunity to discuss and make amendments to the HTA.

2.5 Work as Imagined vs. Work as Done

The comparison of WAI (action cards) and WAD (scenario cards) HTAs was a two-staged analysis. The first stage consisted of highlighting the similarities and differ-

ences between WAI HTAs and corresponding scenario card WAD HTAs. The second stage involved a deeper analysis of understanding similarities and differences in tasks between WAI and WAD.

2.6 Ethical approvals, good practice, and recruitment

Ethical approval was given by the Loughborough University sub-committee (C17-22) and NHS Health Research Authority (HRA) ethical approval (Integrated Research Application (IRAS) (219968). Trust specific Research and Development (R&D) department approval was also given. Data collection methods anonymized responses and participants' details in accordance with the Data Protection Act (1998) [21]. First receivers were recruited by placing posters in staff only areas in the ED and by SR attending staff handovers.

3 Results

Both types of HTAs were verified by the hospital CBRN lead and were later reviewed by Ergonomists as a service evaluation of the CBRN plan.

3.1 Work as Imagined

Two types of HTAs were used to represent WAI. The first HTA visualized the general organizational responsibilities of the hospital during a CBRN event (Figure 1), which were to 1) understand roles and responsibilities 2) take notification of casualties 3) establish command and control 4) activate CBRN plan 5) manage scene 6) decontaminate 7) initiate recovery and 8) debrief.

Figure 1: Superordinate tasks of Trust A general organisational responsibilities during a CBRN event

The analyses of the general organizational responsibilities highlighted a limitation within the plan in superordinate task 6. (carry out required decontamination procedure) with repetition and a crossover of information. As the focus of this study was the ED, the first superordinate task of understanding the roles and responsibilities required from the ED during a CBRN are further described in figure 2 as 7 subtasks. The 7 subtasks are achieved by first receivers as shown in table 1.

Figure 2: Subordinate tasks of Trust A ED responsibilities during a CBRN event

Table 1: Trust A WAI action cards and corresponding first receiver responsibilities

Action card	Responsibilities
Receptionist	1.2.1
Nurse in charge	1.2.2, 1.2.4, 1.2.5, 1.2.6
Doctor in Charge	1.2.2, 1.2.4, 1.2.5, 1.2.6
Decontamination nurse (team leader)	1.2.3, 1.2.4, 1.2.7
Triage disrobing nurse (dry decontamination)	1.2.3
Triage disrobing nurse (wet decontamination)	1.2.3
Healthcare Assistant	1.2.3
Timing board nurse	1.2.2
Exit nurses	1.2.3
Assessment doctor	1.2.2
PPE buddy donning PRPS*	1.2.3
PPE buddy doffing PRPS	1.2.3
PPE buddy enhanced biological precautions	1.2.3
PPE buddy strict biological precautions	1.2.3
Porter	1.2.3
Security	1.2.1, 1.2.6
Medical physics	1.2.2

The second WAI HTA (n=17) represented actions required from first receivers during a CBRN event. Action card superordinate tasks were to 1) prepare to respond to CBRN incident 2) respond to CBRN incident 3) initiate recovery from CBRN incident and 4) document CBRN incident as shown in Figure 3. It was identified that there was ambiguous guidance on how to document the event and what to do with the documentation after the event. This was discussed with the CBRN lead as part of the constructive evaluation of the action cards.

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Figure 3: Trust A WAI (assessment doctor action card) vs. WAD (ED registrar responding to ARS patient)

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3.2 Work as Done

The key actions first receivers described for the CBRN response were grouped as: containing the contaminant, communicating with first receivers and the command team, diagnosing the presenting condition, escalating to seniors, investigating symptoms and contaminant, implementing PPE, preventing cross contamination, protecting colleagues and the work environment, and treating the patient.

3.3 Work as Imagined vs. Work as Done

The comparison of WAI and WAD HTAs highlighted common actions such as isolating the patient, escalating the patient presentation to a senior first receiver, and activating the CBRN plan. Further analyses revealed common tasks across WAI HTAs, for example the decontamination team leader would be required to lead decontamination, implement PPE, contain the contaminant, and communicate with first receivers and emergency services. Such tasks were also evident for the WAD HTAs, in which first receivers would take lead of the situation, implement PPE, contain the contaminant, and communicate. Emerging from the results, differences between WAI and WAD were evident in the importance placed on 1) documentation of the CBRN event 2) treating the patient and 3) diagnosing the presenting complaint, as shown in Figure 3.

4 Discussion

This study has taken a rigorous, and systematic approach using the HF/E method (HTA) and theory (WAI vs. WAD) to better understand the ED response to CBRN events. This study found both commonalities and differences between WAI and WAD in the ED CBRN response.

Common actions emerged from both the action card HTAs and scenario card HTAs, confirming an alignment between WAI and WAD. This alignment was evidenced through actions such as isolation, escalation to senior first receivers, and activating the CBRN plan. Common tasks were also evident across WAI and WAD, such as taking lead, implementing PPE, containing the contaminant, and communicating. These actions and tasks present a continuum between WAI and WAD in the ED response to CBRN events, to minimise the risk of secondary contamination - a known phenomenon in acute hospitals when responding to chemical events in particular [22].

This study found three key differences between WAI and WAD, these were the emphasis placed on 1) documentation of the CBRN event 2) treating the patient and 3) diagnosing the presenting complaint.

Documentation of the actions taken during a CBRN event was stressed to be a legal requirement in the action cards; however, none of the first receivers discussed documentation during the WAD phase. A lack of emphasis on documentation can be

explained by the interruptive and multi-tasking nature of the ED which has been reported to delay or divert from documenting efficiently [23].

Additional differences between WAI and WAD were that action cards did not prioritise treating or diagnosing the patient, but these were described as WAD responses. A possible explanation for the difference between WAI and WAD is through the prioritisation of tasks vs. prioritisation of patients needs dichotomy, which includes assessment, treatment, and diagnosis. WAI prioritised tasks such as documentation and effective decontamination, whereas first receivers (WAD), prioritised patients needs. Although priority is given to minimise the number of deaths, it is advised to prioritise decontamination procedures to reduce casualties exposure to CBRN materials prior to clinical treatment [24]. Therefore, the importance of tasks such as documentation and decontamination should be clearly prioritised in future CBRN plans while taking into consideration the complexities of an interruptive ED environment.

4.1 Limitations

Although a realistic representation of WAD was achieved by carrying out the scenario card presentations in the ED, CBRN events could not ethically be anticipated or created due to their life endangering nature. This was addressed by using realistic scenario cards based on Health Protection Agency CBRN clinical guidance [25] and reviewed by a Hazardous Area Response Team specialist prior to data collection.

4.2 Conclusion

This study has analyzed the ED response to CBRN events using HTA. It was found that the implementation of WAI and WAD had both an alignment and misalignment between policy and practice. The alignment existed in tasks set out by CBRN plans (e.g. implementing PPE and taking lead); the misalignment was a result of the prioritization of tasks (documentation) within the CBRN plan and the prioritization of the patients needs (treatment and diagnosis) by first receivers. Future work should focus on the differences in task priorities between WAI and WAD to enhance clinical practice in the ED response to CBRN events.

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