



# What components of emergency preparedness exercises improve healthcare practitioners' emergency response learning?

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## ABSTRACT

Emergency planning exercises are commonly used to test the capability of healthcare systems to respond to major incidents. However, limited research has examined whether these exercises improve response learning for staff and, if so, what components are vital for achieving this learning. This study assesses the impact of an exercise methodology commonly used to promote emergency preparedness in UK healthcare staff, Emergo Train System (ETS), on healthcare practitioners' perceptions of learning regarding major incident response and identifies what components facilitate these perceptions of improved learning. A mixed method design was adopted, consisting of 83 pre- and post-exercise questionnaires and 10 semi-structured interviews collected from four ETS exercises. Paired Sample t-tests were conducted to identify changes in perceptions pre- and post-exercise, and stepwise multiple regression analysis was conducted to identify what exercise components facilitated perceptions of improved learning. Thematic analysis helped to understand further why healthcare practitioners felt these factors were important for improving learning. Findings showed that healthcare practitioners' confidence and perceptions of personal and organisational preparedness, multi-agency response and teamwork significantly improved post ETS. They believed that emergency response learning was facilitated by level of effort invested in preparatory activities prior to the exercise, exercise realism and frequency. Healthcare professionals believe that ETS exercises have the potential to improve emergency preparedness across individual, team, agency and multi-agency levels, provided that scenarios are realistic, relevant agencies and roles are involved, responders are able and motivated to invest in preparing for exercises, and exercises are run regularly.

## 1. Introduction

In the UK, the term 'major incident' (MI) is used to refer to emergencies that present "serious threat to the health of the community or causes such numbers or types of casualties, as to require special arrangements to be implemented" [22]; p. [7], such as natural disasters, terrorist attacks, and pandemics. Often occurring without warning, these complex and dynamic events are characterized by time pressure, risk, uncertainty, and lack of, excessive or conflicting information [9–11,40]. Managing them requires an effective coordinated multiagency response across emergency services and associated agencies [41]. As events such as the Manchester Arena bombing highlight, the medical community plays a vital role in responding to MIs and is expected to be prepared [40]. With the rarity and novelty of MIs limiting opportunities for healthcare practitioners to gain regular first-hand experience of managing these incidents, emergency planning exercises (EPEs) play a critical role [12],

both for testing the capability of systems to deal with MIs and for training responders [15]. Indeed, UK healthcare and emergency services have a legal requirement to regularly participate in EPEs to strengthen their preparedness [8].

However, despite the central role that EPEs play in emergency planning, little is known about what aspects of these exercises are important for improving healthcare practitioners' responses to MIs, which poses implications for training effectiveness. In order to contribute to developing this body of knowledge, the following study focuses on one form of operation-based exercise methodology commonly used by healthcare services in the UK and worldwide, Emergo Train System® (ETS). We assess the impact of ETS exercises on healthcare practitioners' perceptions of learning regarding MI response and identify what components facilitate these perceptions of improved learning.

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### 1.1. Emergency planning exercises

Overall, EPEs provide opportunities for practitioners to practice creative problem solving, decision-making, and team-based skills such as developing shared situation awareness, coordination and information sharing [5,20,29,40]. These exercises can be divided into two major types - discussion- and operation-based. Discussion-based exercises engage participants in facilitated discussions with response partners regarding how they would address challenges presented in exercise scenarios in order to familiarize them with emergency plans, roles and responsibilities [12]. Operation-based exercises involve functional elements and may take the form of drills, functional or full-scale exercises depending on emergency preparedness objectives [3,12]. For example, drills are used to test a specific function under the response plan, typically within a single entity and involving operational staff. Functional or command-post exercises (FX/CPX) are broader in administrative scope than drills, involve both operational and tactical/strategic staff, and focus on testing situational awareness, coordination, command, and control between multi-agency coordination centres [31]. The most complex type of operation-based exercise is a full-scale exercise (FSX), which is conducted to test all major parts of functions specified in the response plan, offering the greatest level of realism compared to other EPEs [3].

One exercise methodology commonly used by health services in the UK, as well as in over 34 countries worldwide, is the Emergo Train System® (ETS). ETS is a low-fidelity operation-based exercise [34], focusing on reproducing the psychological rather than physical features of a MI. Prior to the exercise, healthcare professionals have the opportunity to review their emergency plans, and are provided with exercise aims and objectives, along with receiving training in order to familiarize them with the exercise conduct and rules. However, information about the exercise scenario is not shared pre-exercise in order to preserve the element of novelty and increase the realism of the exercise. During the exercise, magnetic whiteboards are used to represent the locations relevant to the incident, such as incident site and various hospital departments (emergency department, intensive care unit, operation theatres). On these boards, puppets represent casualties with detailed information about their injuries, physical characteristics and treatment time, while resources are represented by figures of staff, rescue and transport units. By using a bank of 800 ETS casualties representing various types of injuries, a wide range of scenarios can be simulated. Depending on exercise aims and objectives, the ETS can be delivered as a drill for training purposes within a single hospital, or as a FX or CPX to test system response capabilities, such as regional Major Trauma Network (MTN) response to a mass casualty incident (MCI) [34]. This study focuses on the use of ETS as a FX for use in regional MTNs to respond to MCIs.

To date, health emergency preparedness exercises (HEPEs) have predominantly focused on testing organisational preparedness, and various organisational benefits have been reported, including identification of limitations and gaps in emergency plans and protocols, improved communication between and within agencies, and improved collaboration and partnership [32]. Benefits for participating staff have also been reported, including improvements in confidence, understanding of own roles and those of partner agencies, and knowledge of policies, procedures and emergency plans. However, less is known about the particular exercise components that are vital for achieving learning [18,42]. One feature that has been noted as important for translating learning to practice is exercise realism (high fidelity), and full-scale live exercises (FSX) are known for offering the greatest level of realism by replicating environment, resources and conditions of a real MI as close as possible [43]. However, the financial, time and resource costs of FSX can make them impractical [13,14]. Realistic scenarios and information (e.g., on available resources, staff, transport and treatment times) also contribute to exercise realism by supporting decision making to ensure functional fidelity [1,36] and the growing body of evidence points to the

departure from focusing on physical fidelity in simulation-based exercises (replication of physical elements involved in a specific response) to achieve functional fidelity [17]. However, lack of exercise realism may encourage a false sense of confidence [3].

Another feature noted to enhance learning from EPEs is the exercise preparation, including use of lectures, reading materials and quizzes. Pre-exercise preparation can help participants to identify gaps in knowledge, policy or procedures, which is important for setting clear goals to focus on during exercises [37]. The role of exercise facilitators in enhancing learning experience has also been acknowledged as having an impact on participants' learning from EPEs [32].

### 1.2. Current study

Despite the growing body of evidence highlighting the benefits, research is still in its infancy with regards to understanding what aspects of HEPEs are important for improving preparedness and why [3,32]. This study adopts a mixed-method approach in order to understand the effectiveness of low-cost, low-fidelity operation-based ETS exercises in preparing healthcare providers and identify what exercise features are important for improving learning in relation to emergency preparedness. This knowledge poses important implications for enhancing the effectiveness of HEPE design and delivery to better prepare healthcare professionals to respond to MIs.

## 2. Method

### 2.1. Participants

A parallel approach mixed-method design was adopted, with qualitative and quantitative data being collected and analysed simultaneously to validate and complement one another [38]. Quantitative data was collected via an anonymous on-line survey with healthcare practitioners who participated in one of four ETS exercises delivered by Public Health England (PHE) in four different regions of England between 2017 and 2018 (North West, North East, South West, South East). The aim of all four exercises was to allow NHS (National Health Service) providers within different MTNs to practice responding to a MCI. The scenario for all four exercises was similar, consisting of a marauding terrorist fire-arms attack (MTFA) on either a shopping centre (Exercises Tartar and Golden Eagle) or a large bus station (Exercises Blue Peter and Kestrel).

An invitation to take part in the research was sent to all exercise participants by the PHE exercise delivery team on behalf of the researchers two weeks prior to their exercise. Consenting healthcare practitioners were sent two electronic self-report questionnaires to complete, one prior to taking part in one of the exercises and the other after they had participated in an exercise. Healthcare practitioners received two e-mail reminders from the researchers to complete the pre- and the post-exercise questionnaires. Of the 750 healthcare professionals that took part in one of the four ETS exercises, 238 (32%) completed the pre-exercise questionnaire. However, only 95 (13%) completed both the pre- and post-exercise questionnaires, and only 83 (11%) questionnaires contributed to the analysis (age  $M = 45.6$  years,  $SD = 8.9$ ; 10 participants from Tartar, 25 from Golden Eagle, 35 from Blue Peter, and 13 from Kestrel). Data from 12 participants was excluded because they took part in their exercise as a facilitator. Participants were also given the option to leave contact details at the end of the questionnaire if they were willing to participate in a semi-structured telephone interview. Interviews were conducted with 10 healthcare practitioners within two months of the exercise (see Table 1 for participant details).

### 2.2. Data collection and analysis

#### 2.2.1. Quantitative data

The pre- and post-exercise self-report questionnaires were designed

**Table 1**  
Participant details.

	Questionnaires	Interviews
Number of participants	83	10
Organisation	53 female, 30 male 57 NHS trust 7 Ambulance 9 NHS England 4 Clinical Commissioning Group 6 did not disclose	7 female, 3 male 10 NHS trust
Role	34 clinical 25 managerial 4 emergency planning 4 communication 2 scientific 14 other role	3 clinical 7 managerial
Experience in role	50 < five years 19 6–10 years 14 > 10 years	7 < five years 3 6–10 years
ETS exercise role	58 operational 16 tactical 9 strategic	8 Operational 1 tactical 1 strategic

and validated by PHE [35]. Both questionnaires consisted of a series of scales with multiple items and a 6-point Likert response (1 = strongly disagree; 2 = disagree; 3 = slightly disagree; 4 = slightly agree; 5 = agree; 6 = strongly agree; participants could also assign a score of '0' if they felt the statement was not applicable to their role). Both the pre- and post-exercise questionnaires contained the Participants' Perceptions scale comprising the following sub-scales (see Appendix for a copy of questionnaires):

- i. Training and preparedness (Cronbach's alpha = 0.82): comprised of four statements that measured perceptions of how well training received to date had prepared healthcare professionals for responding to major incidents. (For example, *'The overall training I have received to date has prepared me well to respond to a major incident.'*)
- ii. Teamwork (Cronbach's alpha = 0.84): comprised of four statements measuring perceptions of team effectiveness. (For example, *'I have confidence in my team's ability to respond in a major incident.'*)
- iii. Appropriateness of resources (Cronbach's alpha = 0.82): comprised of four statements measuring perceptions of suitability of available resources and knowledge of how to request mutual support for managing major incidents. (For example, *'Our organisation understands how to request mutual aid support.'*)
- iv. Multi-agency response (Cronbach's alpha = 0.82): comprised of five statements measuring perceptions of knowledge and ability to work with other agencies. (For example, *'I understand other agencies' roles during a major incident.'*)
- v. Emergency plans (Cronbach's alpha = 0.93): comprised of seven statements measuring confidence in effectiveness of emergency plans. (For example, *'I have confidence in our organisation's incident plan.'*)
- vi. Organisational preparedness (Cronbach's alpha = 0.88): comprised of five statements measuring confidence in how prepared healthcare professionals' organisations are to respond to a major incident. (For example, *'I am confident that my organisation can respond effectively in a major incident.'*)
- vii. Competency-based knowledge and skills (Cronbach's alpha = 0.89): comprised of six statements measuring perceptions of healthcare professionals' ability to describe their own and their organisation's role in responding to a major incident. (For example, *'I can describe my functional roles and responsibilities in a major incident.'*)
- viii. Anxiety level: comprised of one statement measuring how anxious healthcare professionals felt about responding to a major

incident. (For example, *'I feel anxious when thinking about taking part in a major incident response.'*)

- ix. Confidence in dealing with major incidents: comprised of one item measuring confidence in ability to respond to a major incident. (For example, *'If a major incident occurred today, I would feel confident to take part in the response.'*)

In addition, the pre-exercise questionnaire also included the following scale:

- x. Exercise preparation (Cronbach's alpha = 0.82): comprised of 14 statements that measured perceived motivation and level of investment in activities undertaken to prepare for the exercise, such as identifying exercise aims, personal role, and setting personal objectives. (For example, *'I have identified my personal objectives for this exercise'* and *'I understand the aim of the exercise'*.)

The post-exercise questionnaire also contained the following additional scales:

- xi. Learning after the exercise (Cronbach's alpha = 0.87): comprised of four items measuring perceptions of how effective the exercise was for identifying gaps in emergency preparedness knowledge and providing a platform for practicing applying knowledge and skills that are transferable to a real incident. (For example, *'The exercise has identified gaps in my emergency preparedness knowledge/training'* and *'I will translate the learning from this exercise to my day job'*.)
- xii. Presence of key players (Cronbach's alpha = 0.82): comprised of three items measuring perceptions of the extent to which the exercise contained key roles from across agencies that would be involved in responding to a real major incident. (For example, *'Key individuals who would direct the organisation's response participated in the exercise.'*)
- xiii. Exercise format (Cronbach's alpha = 0.81): comprised of three statements measuring perceptions of how clearly the exercise ground rules were explained. (For example, *'Exercise rules were clearly explained.'*)
- xiv. Exercise scenario (Cronbach's alpha = 0.74): comprised of four statements measuring perceptions of how realistic and challenging the exercise scenario and time pressure was to healthcare professionals' roles. (For example, *'The exercise scenario triggered actions that were relevant to my response roles and responsibilities'* and *'The time pressure exerted in the exercise was appropriate.'*)
- xv. Evaluation process (Cronbach's alpha = 0.62): comprised of three statements measuring perceptions of the objectivity of the evaluation process and ability to share feedback during the debrief. (For example, *'I was able to share my feedback on the performance in the exercise.'*)

All scales showed good internal consistency ( $\alpha \geq 0.7$ ), except for 'Evaluation Process', which has been removed from subsequent analysis. Some statements were not applicable to all participants, causing outliers. Accordingly, participants were removed from analysis for scales where they did not answer all of the questions.

### 2.2.2. Analysis of quantitative data

All quantitative data was analysed using SPSS version 20. To study the exercise's effect on participant perception of emergency preparedness, paired sample t-tests were conducted on pre- and post-exercise responses of the Participants' Perceptions scale including: i) Training and preparedness; ii) Teamwork; iii) Appropriateness of resources; iv) Multi-agency response; v) Emergency Plans; vi) Organisational preparedness; vii) Competency based knowledge and skills; xiii) Anxiety level; and ix) Confidence in dealing with mass casualty incidents. Although data was not normally distributed, the sample size makes it

unlikely that this will affect the veracity of findings [28], and non-parametric alternatives (Wilcoxon Signed Rank) showed similar results.

The dependent variable 'Training effectiveness' (Cronbach's alpha = 0.85) was measured by adding together the post-exercise scores for i) Training and preparedness; ii) Teamwork; iii) Appropriateness of resources; iv) Multi-agency response; v) Emergency Plans; vi) Organisational preparedness; vii) Competency based knowledge and skills; viii) Anxiety level; ix) Confidence in dealing with mass casualty incidents; and x) Learning after the exercise. This amalgamated score represents the total knowledge, learning and confidence healthcare practitioners perceived they had after participating in the exercise. In order to explore what exercise features predicted 'Training effectiveness', stepwise multiple linear regression was conducted (entry  $\alpha = 0.05$ , removal  $\alpha = 0.10$ ) using variables relating to i) Exercise preparation and exercise delivery (e.g., ii) Presence of key players; iii) Exercise scenario; and iv) Exercise format) as the predictor variables.

### 2.2.3. Qualitative data

In the post-exercise questionnaire, participants could leave their e-mail address if they were interested in participating in a follow-up interview to discuss their experiences of participating in the ETS exercise. They were sent an information sheet with further details about the semi-structured interviews, including examples of the questions that would be asked. Healthcare professionals that were still interested in participating could then contact researchers to arrange an interview. During the interview, they could skip questions and were able to end the interview at any time. Interviews were recorded, transcribed (removing personal identifying information in the process), and analysed throughout the recruitment process, which continued until data saturation was reached [16]. The qualitative research literature suggests this can occur between six and 12 interviews [4]. Within the current study, data saturation was achieved in 10 interviews.

Interviews focused on gaining a more in-depth understanding of healthcare professionals' perceptions of exercise delivery and what features facilitated and hindered their learning in relation to responding to MIs, and why. Rather than asking leading questions that specifically related to variables measured in the questionnaires, interview questions were structured to be open to allow participants to provide feedback on the features of exercises that they felt were most pertinent to facilitating and hindering emergency response preparedness. Interviews began with questions to gather background information on exercise role (e.g., *What was your emergency role in this exercise? How comfortable were you with this role?*). The interview then focused on what skills and knowledge healthcare professionals' perceived were most important for an effective emergency response and why (e.g., *What are the most important skills and knowledge needed for an effective emergency response role and why?*), how these skills could be best developed (e.g., *How do you think these skills could be best developed*), what features of the ETS exercise were beneficial for helping to develop these skills (e.g., *What aspects of the exercise helped you to improve your preparedness for dealing with a real emergency?*), and how this type of exercise could be improved to better facilitate learning (e.g., *Do you have any suggestions for how exercises such as this could be improved in order to enhance learning and preparedness?*).

### 2.2.4. Qualitative analysis

Interviews were recorded, transcribed verbatim and analysed using NVivo® software version 12 (average length = 19 min, ranged from 11 to 35 min). Qualitative data was analysed using a data-driven, inductive thematic analysis approach [6] in order to explore healthcare practitioners' perceptions of the benefits of participating in an ETS exercise and what exercise features improve emergency preparedness.

Within the qualitative literature, there is debate regarding the use of intercoder reliability (ICR), with some arguing that it is beneficial for demonstrating trustworthiness, transparency, and consistency [25], whilst others argue that the role of qualitative researchers is to apply

their expertise to the interpretation of varied perspectives on an issue rather than to reveal a universally objective truth [2]. Within the current study, ICR was conducted during the early stages of coding in order to assess the robustness and application of the coding frame developed [19]. A second rater viewed 22% of the same dataset and categorised data units using the coding frame. Cohen's Kappa showed substantial agreement ( $k = 0.801$ ,  $p < .001$ ) [23]. Discussion between the first and second rater helped to clarify the precise meaning of each code, and when both raters reanalysed this subset of data, complete agreement was achieved.

## 3. Results

### 3.1. Quantitative data

Paired sample t-tests (Table 2) identified significant improvements in healthcare practitioners' perceptions of emergency preparedness post-exercise. Respondents' perceptions of their own skills and knowledge significantly increased post-exercise. Perceptions of teamwork and multi-agency response also significantly increased, indicating improved collaboration. In addition, respondents' confidence in their organisations' ability to deal with a MI, including appropriateness of resources, and effectiveness of emergency plans and preparations also increased. Findings indicate that ETS exercises help to reduce feelings of anxiety, while boosting perceived confidence in dealing with a MI. Even when a conservative Bonferroni correction for multiple hypothesis testing ( $\alpha \leq .006$ ) is applied, findings still show significant improvements in confidence in ability to deal with MIs, and perceptions of training and preparedness, teamwork, appropriateness of resources, organisational preparedness, and competency-based knowledge and skills.

To understand what factors influenced *Training effectiveness* ( $M = 191.36.40$ ,  $SD = 23.43$ ), stepwise multiple regression analysis was conducted with the following predictor variables: *Preparation* taken before the exercise, the presence of *Key Players* in the exercise, realism of *Exercise scenario*, and *Exercise format*. All four variables significantly contributed to predicting *Training effectiveness* and this model explained 47.3% of variance ( $F(4,76) = 18.94$ ,  $p < .001$ , *Adjusted R2* = 0.473). Correlations between the predictor and outcome variables are reported in Table 3 and the model summary is reported in Table 4.

**Table 2**

Paired-Sample t-test comparisons pre- and post-exercise perceptions (N = 83).

Variable	Pre-test Mean (SD)	Post-test Mean (SD)	t-test Mean (SD)	df	t	Sig. (1-tailed)
Level of anxiety	3.78 (1.4)	3.48 (1.34)	-0.301 (1.25)	82	-2.201	0.016*
Confidence	4.47 (0.93)	4.90 (0.74)	0.434 (0.77)	82	5.144	0.001***
Training and preparedness	17.14 (3.76)	19.49 (3.01)	2.349 (2.78)	82	7.705	0.001***
Teamwork	18.87 (3.21)	20.14 (2.68)	1.256 (2.78)	81	4.093	0.001***
Appropriateness of resources	16.65 (3.79)	17.53 (3.84)	1.066 (3.13)	75	2.973	0.002**
Multi-agency response	22.51 (5.18)	23.35 (3.61)	0.823 (3.72)	78	1.964	0.027*
Emergency plans	31.48 (5.18)	32.43 (5.57)	0.939 (4.78)	81	1.777	0.039*
Organisational preparedness	22.27 (4.17)	23.28 (4.04)	0.988 (3.08)	80	2.890	0.003**
Competency-based knowledge and skills	27.76 (4.89)	30.08 (3.94)	2.268 (3.73)	81	5.509	0.001***

Note. *SD* = Standard Deviation. *df* = Degrees of Freedom. \* $p < .05$ ; \*\* $p < .005$ ; \*\*\* $p < .001$ .



**Table 3**

Pearson's correlations (r values) between predictor and outcome variables (N = 83).

	Preparation	Key players	Exercise scenario	Exercise format	Training effectiveness
Preparation	–	.08	.20*	.30**	.37**
Key players	.08	–	.35**	.52**	.48**
Exercise scenario	.20*	.35**	–	.47**	.50**
Exercise format	.02	.19*	.47**	–	.62**

\*p < .05; \*\*p < .001.

**Table 4**

Model summary.

Significant predictors	β	t Value	p	R <sup>2</sup>	Adjusted R <sup>2</sup>	F
Exercise format	.618	6.985	.001	.382	.374	48.79*
Exercise format	.489	5.089	.001	.439	.425	30.58*
Exercise scenario	.272	2.83	.006			
Exercise format	.440	4.533	.001	.470	.449	22.77*
Exercise scenario	.259	2.752	.007			
Preparation	.184	2.110	.038			
Exercise format	.343	3.252	.002	.499	.473	18.94*
Exercise scenario	.230	2.470	.016			
Preparation	.204	2.375	.020			
Key players	.202	2.102	.039			

\*p < .001.

3.2. Qualitative data

In total, 41.2% of interview content was coded into six themes. Three of these themes relate to the perceived benefits of participating in the ETS: Experience (15.3%), Cooperation (20.4%), and Evaluation and Adjustment (15.2%). The other three themes refer to factors that healthcare professionals believe promote learning from exercises: Preparation (6.5%), Realism (30.4%), and Regular Practice (12.2%). Details regarding prevalence of themes are provided here for transparency, but prevalence is not equivalent to importance (Braun & Clarke, 2013). Each theme is discussed below, and direct quotes are provided in Tables 5 and 6 to support themes.

3.2.1. Value of exercises in preparing healthcare providers for a major incident response

**Experience:** Responders felt that taking part in ETS exercises was valuable for providing the opportunity to gain first-hand experience of undertaking roles and making key decisions in response to MI scenarios. They believed that this allowed them to better understand their responsibilities and identify potential obstacles that needed adjustment to improve responding. Healthcare practitioners noted that this experience of responding to a complex and dynamic situation increased their knowledge of how to access equipment and relevant information about their organisation's MI plans, which made them feel less anxious and more confident about responding to a MI.

**Cooperation:** Responders felt that participating in an ETS exercise was beneficial for facilitating mutual understanding, teamwork, and collaboration within and between agencies. They noted that having the opportunity to communicate with and witness other agencies responding to challenges presented by the exercise scenario helped them to build familiarity, trust and better understanding of one another's roles and capabilities. As a result, responders felt they would be better able to share necessary information to inform situation awareness and decisions, and allocate resources in future incidents, which is important for achieving common goals.

**Evaluation and adjustment:** Responders commented on the value of ETS exercises for creating conditions to evaluate their organisation's preparedness by testing emergency plans, resources and arrangements.

**Table 5**

Quotes for themes relating to the value of exercises for preparing healthcare providers to respond to major incidents.

Participant Number	Theme	Context	Quote
3	Experience	Quote showing how taking part in the exercise provides insights into roles.	"I think experiencing and practicing that role during the exercise made me realise the complexities of the role itself, not my day-to-day role, but the role as a major incident, at a major incident. Yes, I would change how I would do things, completely"
5			It's where all departments joined up using the JESIP principles, how we adapted them, the intelligence, and then there was the communication between each department as to what we were going to do. I found it very helpful."
6	Cooperation	Quotes highlighting the importance of the exercise for allowing participants to practice and develop their inter-agency teamwork.	"So I was really, I was quite pleased, because this Doctor [unclear] just allowed us to get on with it, because I think he knew that we had it all sorted upstairs."
10			"The coordination with other agencies and the collaboration, having the meetings and actually doing the online learning, to actually, you know, sort of, get a bigger picture. Because you're very much, in that kind of scenario, you are very much, sort of like, a small cog in a very big wheel so you're concentrating on what your cog is doing without actually the awareness of the impact on everybody else."
2	Cooperation	Quotes highlighting the importance of the exercise for allowing participants to practice and develop their inter-agency teamwork.	"It was quite a nice bonding exercise in terms of you really have to work well as a team, there's only three of us. And for the trust I think it was useful, I think it highlighted new areas that we need to look at. So I think, overall I would say that was very good."
5			"It's where all departments joined up using the JESIP principles, how we adapted them, the intelligence, and then there was the communication between each department as to what

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Table 5 (continued)

Participant Number	Theme	Context	Quote
7			we were going to do. I found it very helpful.” “I think the most important part of it was actually seeing how the bigger team work together and how decisions we are doing in our clinical setting then impacted on other parts of the response.”
9			“The coordination with other agencies and the collaboration, having the meetings and actually doing the online learning, to actually, you know, sort of, get a bigger picture.”
1	Evaluation and Adjustment	Quote highlighting the importance of the exercises for identifying how well-prepared organisations are.	“I sound like a manager but being able to deep-dive into our plans and being able to walk them through with departments to see where we would come unstuck, where we might have problems and where things would work well.”
3			“I felt that we tested the regional distribution plan quite effectively and it helped clarify my mind how I would deal with those patients ever if I was involved in a major incident like this as to the decision making around where, which hospitals, trauma centres, trauma units I would send patients to.”
6			“But we feel certainly in like the exercise, the personnel that we’ve got there, if we did get major trauma, we could deal with it.”
10			“I do think I’ve learnt, you know, in terms of having to revise a new emergency plan for this hospital and the action cards, and sort of, what we would do, general organisation of what we would do in this area, how we would facilitate getting emergency patients through, expediting them in a timely and efficient manner, whilst also still keeping the x-ray department running for other patients.”

They believed that exercises allowed them to identify the strengths and risks of plans (time response from people on call, roles present) and resources available (number of beds, staff available, specialist equipment), along with receiving timely feedback on this. Consequently, these healthcare professionals felt better able to take necessary actions to overcome shortcomings identified in order to mitigate problems in

Table 6

Quotes for themes relating to what aspects of exercises promote learning.

Participant Number	Theme	Context	Quote
1	Preparation	Quotes highlighting how to prepare for an ETS exercise.	“I read through anything that was sent through to me from Public Health England about the exercise and I met with the emergency preparedness officers in the week beforehand just to check who would be attending and what roles we would each be taking”
3			“I think more detail on role cards would be useful, a little bit more guidance as to how to manage or how to best sort the patients. Yes, just some better guidelines and SOP around the role I think would be good.”
9			“I did also do the Public Health England online training, which was useful. There are lots of abbreviations and, sort of, acronyms, and you can’t learn them all.”
11			“I suppose because we knew it was happening, we’d prepared ourselves with everything we needed the day before. So, we’d got all of our policies and our plans and our action cards and so on and so forth ready, so that we could just get going the minute we received the notifications, which I suppose, is unreal in itself. But we just wanted to make sure we could do everything that we could.”
3	Realism	Quotes highlighting that realistic exercises can produce realistic responses	“I think the, just having a constant flow of patients, I think we dealt with over 200 patients, so that constant flow and pressure, although it obviously doesn’t completely simulate a real major incident it did simulate the pressure and the intensity of what a major incident would be like in terms of the numbers, which was good.”
5			“But I thought it was very good the way all the casualties, injuries, we’re trying to make it as time orientated as possible, if you know what I mean ... And I think it was really, everybody else being involved in what happens in a major incident and not just pieces of paper being pushed around on a board.”
7			“So I think there was a bit of preparation in terms of getting everyone together beforehand in terms of who was going to attend so we

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Table 6 (continued)

Participant Number	Theme	Context	Quote
8			had all the right people there” “there were sandwiches, and everything was taken care of, but in a real-life situation you’d be exposed to those elements and expected to manage them and so, you know, if we’d have done it outside, regardless of what the weather was, obviously, you know, it’s difficult with pens and boards, but you’d have, you know, you’d get shelters put up and stuff that you would do for real incidents. So, I think taking it, you know, to that next level would be more beneficial, as replicating the real thing, anyway, even if you can’t use real patients.”
2	Regular practice	Quotes highlighting the importance of regular practice	“I mean in an ideal world I suppose you would do some kind of test exercise about that every one or two years. I do think no course could do what that did.”
4			“Just regular practice. I think if that particular exercise was done every six months everyone would be a little bit sharper.”
5			“Well, my recommendations are that we need more of these exercises [...] That’s it, practice makes perfect and in these sorts of scenarios, you make a mistake you’re not going to kill anybody, and you learn from your mistakes.”
8			“We definitely have to do more of these types of exercises. It’s a must.”

future scenarios.

### 3.2.2. Exercise factors promoting learning

**Preparation:** Responders commented that the level of knowledge and learning they were able to gain from participating in an ETS exercise was influenced by how much effort they invested in preparing in advance. They felt that preparation allowed them to better understand how the exercise would run and why, who participates, what they would gain from participating, and knowledge gaps they may want to address. Such knowledge was important for setting goals and improving motivation to engage. Responders suggested that exercise delivery teams could better help them to prepare by ensuring that reading materials were provided in advance, along with a quiz to assess their knowledge and clarify the objectives being tested. Responders commented that having reading material prior to the exercise, along with their organisation allowing them the time to engage in pre-exercise preparations, was important for maximising the learning potential. They also felt that having clear instructions prior to the exercise were important for ensuring that responders know what role they are playing, roles of exercise support staff and how to manage resources and patients across magnetic boards.

**Realism:** Responders noted that participating in exercises was the closest they were likely to come to receiving training for real MIs. They felt that realism was therefore important for enabling them to evaluate and revise their performance in an environment that closely resembled a real-world scenario and robustly tested their abilities and organisational plans and resources. Practitioners commented that realism in the ETS was achieved by including all relevant roles and agencies that would respond to a real incident, choosing scenarios and objectives relevant to them and their agency, ensuring data and information feeds were accurate and realistic, providing tangible consequences for decisions and realistic time and resource pressures.

**Regular Practice:** Responders noted that this type of exercise is an effective preparation method because it offers realistic pressures, provides the opportunity to train with other agencies and to learn in a safe environment. However, to maximise on enhancing learning, they felt these exercises should be delivered regularly to prevent lessons from being forgotten. Comments also highlighted that regular exercising is important for ensuring that all staff with potential responsibility for responding to MIs have the opportunity to engage.

## 4. Discussion

Research to date has tended to focus on the value of emergency exercises for testing preparedness [3,32]. Less attention has been given to examining the value of HEPs for promoting learning regarding MI response, and even less research has examined what components of HEPs are important for improving this learning [32]. Accordingly, this study adopted a mixed method approach to examine a low-fidelity operation-based exercise method commonly used for preparing health emergency response services, the ETS.

Findings from this study show that participation in the ETS exercise improves how well-prepared healthcare professionals perceive themselves to be to respond to a MI. In particular, participation in the ETS improved how well healthcare professionals believed they could understand roles and responsibilities, along with their level of confidence in their ability to fulfil their roles, perceptions that have been shown to be important for implementing emergency plans effectively [30] and for improving performance [34]. In addition, ETS exercises facilitated healthcare professionals’ perceptions of mutual understanding, trust, and collaboration by enhancing understanding of partner agencies’ roles and capabilities. Previous research into multi-agency response to major incidents shows that knowledge of other agencies’ roles and responsibilities is important for improving information sharing, team performance and effective allocation and coordination of resources [39, 40].

In line with Samardzic et al. (2015), findings also show that healthcare practitioners perceive that ETS exercises create conditions relevant for testing strengths and limitations of emergency plans, resources and arrangements, and promote seeking ways to overcome shortcomings. Reductions in the level of anxiety felt by healthcare professionals post ETS may help to improve future incident management by making responders less likely to “freeze” and more likely to make decisions when faced with the psychological pressure of a real MI [21]. It is also important to note that benefits identified from the ETS, which is a low-fidelity simulation, were similar to benefits reported from higher-fidelity simulations that more accurately physically replicate environment (disaster scene) and resources (equipment and simulated patients) [26]. There is evidence that learning from a similar ETS exercise made a significant contribution to the response in a real MI [34].

Furthermore, findings of this study demonstrated that three components were important for improving healthcare professionals’ perceptions of how much they had learned by participating in an ETS exercise. Firstly, these practitioners felt that preparing in advance of exercises was important, including reviewing emergency plans and receiving information from the exercise delivery team about the value of the exercise, how it would run and why. These activities may assist

responders to identify goals and knowledge gaps to focus on during exercises, along with clarifying objectives being tested [32,37]. This is consistent with experiential learning models requiring prior knowledge in order to benefit from experience [1] and pre-exercise knowledge is important to benefit from HEPEs [27]. Healthcare professionals also highlighted that it was important to provide clear instruction on how to take part in the exercise, including clarity of supporting roles, pressures and rules [5].

Another component identified by healthcare professionals as being important to learning was exercise realism. These practitioners perceived that the realism offered in the ETS allowed them to practice their roles as well as evaluate and revise how their actions and interactions would affect an incident, by ensuring all relevant roles and agencies that would respond to a MI are present (social fidelity), choosing scenarios and objectives relevant to responders, applying realistic resource and time pressure and using accurate input data to support decisions (functional fidelity). Realism in the ETS was achieved through maintaining functional and social fidelity [18], and while environmental and physical fidelity was low, nonetheless healthcare professionals identified multiple learning outcomes. They also emphasised the vital importance of running exercises regularly, six-monthly or yearly, to ensure that lessons learned are remembered, implemented and continually tested, and that all personnel have opportunities to practice in safe learning environments, supporting previous research on improving responding in dynamic incidents [1].

Overall, findings support a growing body of literature that highlights the value of low-fidelity simulation exercises offering high functional and social fidelity in helping to prepare healthcare responders, by improving their perceptions of knowledge of roles, policies, multi-agency response and confidence [24]. However, whilst most studies analyze HEPEs using either qualitative or quantitative post-exercises measurements [33], the present study provides new valuable contribution by using a mixed method design that provides a more comprehensive understanding of the research problem [38].

#### 4.1. Implications

This study provides evidence to support decisions to use ETS-type exercises for preparing healthcare professionals to respond to MIs. Findings provide concrete evidence for exercise planners, facilitators, organisations and individual responders alike in highlighting what features of low-fidelity exercises such as the ETS are important for improving healthcare professionals' perceptions of emergency response learning. In particular, it is vital for responders to have access to pre-exercise materials, such as organisational emergency response plans, exercise aims and objectives, and to have the time to engage in preparation activities in advance of exercises in order to set clear goals to focus on during the exercise. It is also vital to ensure that exercises are realistic, including realistic representation of roles, accurate information, consequences for decisions and actions taken and the timescales and levels of resources available. In addition, exercises should be repeated frequently in order to ensure that all relevant staff have the opportunity to learn in a safe environment.

#### 4.2. Limitations and future research

Despite the important contribution of these findings, the study is not without limitations, including the relatively limited sample size of 83 participants. While the response rate pre-exercise was higher (32%), only 11% of exercise participants completed both the pre- and post-exercise questionnaires. Findings may therefore be biased by this sample that were motivated to exert additional effort to support this research. Due to the small sample size analysis did not include control for participants' socio-demographic data. It is also important to note that this study measures the self-perceptions of healthcare professionals rather than measuring concrete behaviours in response to a real MI. In

addition, this study specifically focused on the perceptions of healthcare professionals but other category 1 emergency responders, including fire and police, play a central role in responding to MIs. Current findings do not shed light on the effectiveness of ETS exercises in improving perceived response capabilities across other agencies and requires further research to target these populations. Future research focusing on the suitability of ETS exercises for use with category 2 responders would also be beneficial, including exercise cost effectiveness [40]. Further research is also required to understand long-term benefits from the ETS.

#### Data availability

Datasets related to this article are the property of Public Health England and requests to access this data should be directed to Elena Skryabina, [Elena.Skryabina@phe.gov.uk](mailto:Elena.Skryabina@phe.gov.uk).

#### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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#### Appendix

##### Pre-exercise questionnaire

In the following questions, we ask you to share your attitudes towards this exercise and any specific preparations undertaken or experiences. Please indicate on a scale of 1–6 (where 1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, and 6 = strongly agree) the extent to which you agree with the following statements. If you do not feel that the statement is relevant to you, please enter a '0'.

##### Pre exercise preparation:

1. I am motivated to take part in the exercise
2. I understand the aim of the exercise
3. I understand the exercise objectives
4. The exercise objectives are relevant to my emergency role
5. The exercise objectives are relevant to my everyday role
6. The exercise objectives are relevant to my organisation
7. I think the delivery of this exercise is timely
8. I expect that the exercise will be useful for me, personally
9. I have had sufficient time to prepare for this exercise
10. I have identified my personal objectives for this exercise
11. I completed the pre-exercise preparations required by the exercise team
12. This is a valuable exercise

##### Perceptions of training and preparedness:

1. The overall training I have received to date has prepared me well to respond to a major incident
2. I understand the requirements of my role in a major incident



3. I am confident in my abilities to operate effectively in a major incident
4. I have practiced my emergency role in emergency preparedness exercises

*Perceptions of teamwork:*

1. I have confidence in my team's ability to respond in a major incident
2. I believe my team members are competent in their response roles
3. I believe my team know where to get support in a major incident
4. I feel I am a valued member of my team

*Perceptions of the appropriateness of resources:*

1. Our department has the necessary equipment to deal with a large number of casualties
2. I have the right equipment to perform my role in a major incident
3. Our department is able to maintain the supply of necessary resources to a major incident
4. Our organisation understands how to request mutual-aid support

*Perceptions of multi-agency response:*

1. I understand other agencies' roles during a major incident
2. I think other agencies have a good understanding of my organisation's role
3. I am confident that other responding organisations can work effectively in a major incident response
4. I am confident that my organisation can effectively work together with other responding organisations in response to a major incident
5. I am confident that responding organisations have developed shared understanding about the response process and strategies

*Perceptions of emergency plans:*

1. I have confidence in our departmental (local) incident plan
2. I have confidence in our organisation's incident plan
3. I have confidence in our organisation's hazard specific plans
4. I have confidence in the national major incident plan
5. I am confident that my department/team plan complements the organisation's incident plan
6. I am confident that my local plan complements the national plan
7. I believe my organisation's emergency plans are regularly reviewed and updated

*Perceptions of organisational preparedness*

1. I am confident that my organisation can respond effectively in a major incident
2. My department is well prepared to respond in a major incident
3. My organisation is prepared for a multi-agency response
4. Emergency preparedness is a high priority in my organisation
5. My organisation regularly participates in multi-agency training and exercising

*Perceived level of stress:*

1. I feel anxious when thinking about taking part in a major incident response
2. If a major incident occurred today I would feel confident to take part in the response

*Perceptions of competency-based knowledge and skills:*

1. I can describe my functional roles and responsibilities in a major incident

2. I can describe my organisation's role in a major incident
3. I can describe my organisation's coordination (chains of command) in a major incident
4. I can locate my organisation's incident response plan
5. I can describe the role of my organisation in a major incident response in relation to other organisations
6. I am familiar with my organisation's preparedness plans and emergency arrangements

*Post-exercise questionnaire*

In the following questions, we ask you to share your attitudes towards this exercise and any specific preparations undertaken or experiences. Please indicate on a scale of 1–6 (where 1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, and 6 = strongly agree) the extent to which you agree with the following statements. If you do not feel that the statement is relevant to you, please enter a '0'.

*Pre exercise preparation:*

1. I am motivated to take part in the exercise
2. I understand the aim of the exercise
3. I understand the exercise objectives
4. The exercise objectives are relevant to my emergency role
5. The exercise objectives are relevant to my everyday role
6. The exercise objectives are relevant to my organisation
7. I think the delivery of this exercise is timely
8. I expect that the exercise will be useful for me, personally
9. I have had sufficient time to prepare for this exercise
10. I have identified my personal objectives for this exercise
11. I completed the pre-exercise preparations required by the exercise team
12. This is a valuable exercise

*Perceptions of training and preparedness:*

1. The overall training I have received to date has prepared me well to respond to a major incident
2. I understand the requirements of my role in a major incident
3. I am confident in my abilities to operate effectively in a major incident
4. I have practiced my emergency role in emergency preparedness exercises

*Perceptions of teamwork:*

1. I have confidence in my team's ability to respond in a major incident
2. I believe my team members are competent in their response roles
3. I believe my team know where to get support in a major incident
4. I feel I am a valued member of my team

*Perceptions of the appropriateness of resources:*

1. Our department has the necessary equipment to deal with a large number of casualties
2. I have the right equipment to perform my role in a major incident
3. Our department is able to maintain the supply of necessary resources to a major incident
4. Our organisation understands how to request mutual-aid support

*Perceptions of multi-agency response:*

1. I understand other agencies' roles during a major incident
2. I think other agencies have a good understanding of my organisation's role

3. I am confident that other responding organisations can work effectively in a major incident response
4. I am confident that my organisation can effectively work together with other responding organisations in response to a major incident
5. I am confident that responding organisations have developed shared understanding about the response process and strategies

*Perceptions of emergency plans:*

1. I have confidence in our departmental (local) incident plan
2. I have confidence in our organisation's incident plan
3. I have confidence in our organisation's hazard specific plans
4. I have confidence in the national major incident plan
5. I am confident that my department/team plan complements the organisation's incident plan
6. I am confident that my local plan complements the national plan
7. I believe my organisation's emergency plans are regularly reviewed and updated

*Perceptions of organisational preparedness:*

1. I am confident that my organisation can respond effectively in a major incident
2. My department is well prepared to respond in a major incident
3. My organisation is prepared for a multi-agency response
4. Emergency preparedness is a high priority in my organisation
5. My organisation regularly participates in multi-agency training and exercising

*Perceived level of stress:*

1. I feel anxious when thinking about taking part in a major incident response
2. If a major incident occurred today I would feel confident to take part in the response

*Perceptions of competency-based knowledge and skills:*

1. I can describe my functional roles and responsibilities in a major incident
2. I can describe my organisation's role in a major incident
3. I can describe my organisation's coordination (chains of command) in a major incident
4. I can locate my organisation's incident response plan
5. I can describe the role of my organisation in a major incident response in relation to other organisations
6. I am familiar with my organisation's preparedness plans and emergency arrangements

*Exercise aims and objectives:*

1. The exercise aim was achieved
2. The exercise objectives were achieved
3. The exercise objectives were relevant to my emergency role
4. The exercise objectives were relevant to my everyday role
5. The exercise objectives were relevant to my organisation
6. I think the delivery of this exercise was timely

*Exercise scenario:*

1. The exercise scenario presented challenges that were relevant to my organisation
2. The exercise scenario triggered actions that were relevant to my response roles and responsibilities
3. The scenario presented challenges that facilitated learning
4. The time pressure created during the exercise was appropriate

*Exercise format:*

1. Exercise ground rules were clearly explained to me
2. The evaluation process was clear to me
3. The facilitator's roles were explained to me
4. I know when the exercise report will be available to me
5. I understand how the lessons identified in this exercise will be actioned

*Key players:*

1. Key organisations that would be involved in a major response were represented at the exercise
2. Key individuals who would direct the organisation's response participated in the exercise
3. Adequate representation of roles was present or accessible

*Exercise evaluation:*

1. The evaluation process was clear to me
2. The evaluation methodology was objective
3. The post-exercise hot-debrief identified important lessons
4. I was able to share my feedback on the performance in the exercise

*Personal satisfaction with the exercise:*

1. I learned something new from the exercise
2. I feel more confident to respond to a major incident after this exercise
3. The exercise has identified gaps in my emergency preparedness knowledge/training
4. I am motivated to improve my emergency preparedness knowledge
5. I am capable of addressing my training needs highlighted by this exercise
6. I will translate the learning from this exercise to my day job
7. The exercise has identified limitations in plans which, if addressed, will improve organisational emergency preparedness
8. I am confident that the lessons identified will be addressed and embedded
9. I expect to be advised how the lessons identified in the exercise will be addressed
10. I understand who will lead on ensuring the lessons identified will be actioned
11. I am confident I will be updated how the lessons identified were implemented/learned
12. I would recommend this type of exercise to my colleagues
13. I will share learning from this exercise with my colleagues
14. Organisational limitations identified in this exercise are beyond my control

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