

**CREST** Centre for Research and Evidence on Security Threats



# Terrorism-Related Simulations

**FULL REPORT**  
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## FULL REPORT

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This report is one of a series exploring *Knowledge Management Across the Four Counter-Terrorism 'Ps'*. The project looks at areas of policy and practice that fall within the four pillars of CONTEST. For more information visit:  
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# OVERVIEW

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Simulation-based training exercises provide high-fidelity simulations of real-life critical incidents and replicate the challenges faced by individuals when responding to these incidents. They are widely assumed to be an effective tool for improving individual and organisational responses to critical incidents, including terrorist attacks.

Simulations have been shown to produce short-term positive outcomes, such as individual or organisational learning, or helping to identify gaps in existing policies. However, the longer-term effectiveness of simulation-based training is poorly understood, and there are few public evaluations by which to understand their impact.

The evidence-base for terrorism-related simulations is similarly weak. Only nine recent studies were identified that analysed specific terrorism-related simulation exercises. Eight studies examine existing programmes, the vast majority of which only discuss short-term outcomes or participants' opinions of these exercises, and one describes a workshop to create a counter-terrorism training programme. Despite these limitations, it is possible to present an overview of current good practice associated with the design, delivery, and evaluation of terrorism-related simulations.

This report brings together the literature on simulation-based training by drawing on these nine studies of terrorism-related simulations, as well as exercises used to simulate a range of natural and man-made disasters. It discusses how simulations can be used to enhance learning that translates to real-life incidents and outlines the key principles for policymakers to consider when designing and evaluating simulation exercises. It draws on case studies of terrorism-related simulations from the UK, Europe, and North America.

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## KEY POINTS

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- Terrorism-related simulations have been used for a variety of purpose including testing and validating existing plans and procedures; evaluating performance; improving the capabilities and capacities of individuals and organisations to respond to real-life incidents; and identifying gaps in existing training, response plans, protocols and procedures.
- Simulation-based training exercises have been shown to produce short-term learning outcomes. Simulations can increase self-reported confidence in, and knowledge of, emergency response protocols and procedures, and can enhance technical and non-technical skills.
- The longer-term impact of terrorism-related simulations is poorly understood. Only one study was identified that evaluated the impact of terrorism-related simulations on a real-life incident, and studies that evaluate the longer-term impact of such simulations are lacking.
- There are several important factors to consider when designing and delivering simulations. Simulations must realistically recreate the complexity, uncertainty and dynamic nature of real-life incidents, and test the technical and non-technical skills, such as collaboration and coordination between different agencies, that are crucial for an effective response.
- Simulation exercises should include opportunities for feedback and debriefing to enhance learning. While not specific to terrorism, one study that analysed performance indicators from evaluations of 46 training exercises (e.g. simulator reports, game scores, hospital records, self-ratings, performance ratings) reported that effective debriefing improved performance against these metrics by approximately 25 per cent when compared to control groups that did not attend a debrief. As one of the few studies that uses a counterfactual to evaluate the impact of specific

features of training exercises, this is one of the more robust findings in the literature.

- Evaluating the longer-term effectiveness of simulations is challenging. The relative infrequency of terrorist attacks means that it is difficult to evaluate how effective simulations have been in preparing responders in dealing with real-life incidents. Evaluators also face practical challenges in accessing the data that could be used to evaluate responses to real-life attacks.
- A range of different data collection and evaluation methodologies have been used to evaluate the impact of simulations on learning, behaviour, and outcomes. Common approaches include pre- and post-simulation surveys and follow-up interviews. While these methods are effective at recording shorter-term outcomes and claimed longer-term impacts, more consideration needs to be given to how best to capture longer-term impacts on behaviour and performance.

# INTRODUCTION<sup>1</sup>

Cabinet Office guidelines state that ‘Planning for emergencies cannot be considered reliable until it is exercised and has proved to be workable, especially since false confidence may be placed in the integrity of a written plan.’ However, because mass-casualty incidents such as terrorist attacks are rare, there are few opportunities to evaluate the effectiveness of procedures and protocols for responding to such incidents. The Civil Contingencies Act 2004, therefore, requires Category 1 responders – organisations ‘at the core of the response to most emergencies’ such as the emergency services, local authorities and NHS bodies – to deliver regular simulations of emergency situations.

These exercises have been used to simulate a range of natural and man-made disasters, including terrorism. Simulations serve three main purposes: to validate plans; to develop staff competencies and give them practice in carrying out their roles in the plan; and to test well-established procedures. Because of their perceived effectiveness, simulation-based exercises are increasingly being used around the world to test existing procedures and policies; identify issues and gaps that need to be addressed; and build the knowledge, and the technical and non-technical skills, that emergency responders need.

There are several types of exercise or simulation that can be used to test counter-terrorism procedures, each of which is designed to deliver specific individual and organisational objectives over the short and long-term (see table below). This report brings together empirical evidence relating to the use and effectiveness of terrorism-related simulations based on academic and grey literature produced from 2017 onwards. Because of the limited literature on this topic, where relevant, it draws on studies from outside of this period; more theoretical studies that have outlined areas of good practice relating to the design, delivery and evaluation of these simulations; and insights from broader studies of simulation-based training. The research is international in scope, drawing on insights from the UK, Europe, and the USA.

This report should be considered exploratory as there is an absence of robust evidence through which to assess the effectiveness of terrorism-related simulations. Many studies are based on small samples, and the metrics used to assess effectiveness often draw on self-reported short-term outcomes, such as levels of satisfaction or preparedness. Further research into the longer-term effects of simulation exercises and the impact that simulations have on real-life incidents is needed.

Exercise Category	Exercise Type	Exercise Features	Exercise Objectives
Discussion-Based	Seminar	Informal discussion or lecture	Organisational: Identify improvements in plans.
	Workshop	Used to build plans or policies	Organisational: Develop specific emergency plans or policies.
	Tabletop	Facilitated discussion of a simulated emergency	Organisational: Assess plans, policies and procedures; Individual: Training and learning.
Operation-Based or Live Exercises	Drill	Coordinated activity to test a specific operation or function	Individual & Organisational: Test training, response time etc.
	Functional / Command Post	Examines coordination between multiple agencies	Individual & Organisational: Test and evaluate response capability.
	Field / Full-Scale	Multi-agency exercise testing all functions of response plan	Individual & Organisational: Test and evaluate plans in real-time.

<sup>1</sup> Typology of exercises and their purpose is based on *Skryabina et al. (2017)*. Government guidelines are drawn from *HMG (2014)*.

# THE RATIONALE FOR SIMULATION-BASED TRAINING<sup>2</sup>

When delivered effectively, simulation-based training exercises can have 'dual value' in producing both individual-level and organisational/system-level effects. Based on a review of 86 evaluations of disaster preparedness exercises, including a significant number of simulated bioterrorism exercises, one report outlined a series of potential individual and organisational benefits of simulation-based exercises:

- Individual benefits include improved understanding of individual and organisational roles in response planning; increased confidence in knowing how to respond to incidents; greater knowledge of topics such as the threat from terrorism; satisfaction with simulation-based sessions; and improved competence in technical skills, as well as non-technical skills such as collaborative working or communication skills. Current studies largely draw on self-reported data, but more robust competency or knowledge tests could be used to assess this effect.
- Organisational benefits include identifying gaps in plans or training; having the ability to practice and to test an emergency plan, and to test staff training; and improving communication and collaboration within and between different organisations. In a

minority of studies, simulations have been shown to contribute to how agencies responded to real-life incidents.

Different forms of simulation can be used to achieve different objectives:

- Discussion-based exercises involve a facilitated discussion of a critical incident response. These exercises are useful for introducing and developing new plans or procedures, improving knowledge and awareness of existing procedures, and identifying gaps.
- Operation-based exercises are practical exercises in which response plans, or specific elements of a response plan, are tested or validated. These exercises can help to improve individual knowledge of roles and responsibilities and build the technical and non-technical (e.g. teamwork, coordination) skills required for an effective response. They also provide a more thorough means by which to identify gaps and limitations in existing procedures and training.
- Both discussion- and operation-based exercises are useful research tools that can be used both to train participants and to assess their current level of preparedness (see box below).

## THE UTILITY OF SIMULATION-BASED TRAINING AS A RESEARCH TOOL

*Alison et al. (2012) argue that simulation-based training maximises the strengths of laboratory and field-based training by acting as a 'halfway house' between the two approaches:*

- Simulations 'enable researchers to develop an understanding of the social, organisational, cultural, and political contexts in which decisions are made, while maintaining experimental control by selecting the context they wish to expose decision makers to'
- Simulations can also 'be effectively designed with a dual emphasis on both researching and training the psychological (social and cognitive) processes and non-technical skills involved during the effective management of dynamic and challenging situations.'

<sup>2</sup> This rationale is adapted from *Skryabina et al. (2020)* and from *Alison et al. (2012)*, with the former discussing the 'dual value' of simulations. The review of 86 publications was conducted by *Skryabina et al. (2017)*.

## THE RATIONALE FOR SIMULATION-BASED TRAINING

### Terrorism-Related Simulations

More research is needed into the longer-term effects of simulations. While the earlier mentioned review of 86 different evaluation reports found that simulations often have immediate individual and organisational benefits, it also commented that ‘published evidence of exercises’ impact on individual and organisational levels of emergency preparedness and response over the long term is very limited’.

This evidence base about the longer-term impacts of terrorism-related simulations is particularly weak. Most of the evidence used to evaluate effectiveness is based on self-reported data collected from a subset of participants that only captures short-term learning or attitudinal outcomes. Potential solutions to this evidence gap include re-running simulations periodically to track performance over time; assessing responses to real-life incidents to evaluate the impact of simulations on actual preparedness; and using more longitudinal data collection methodologies.



# THE CURRENT USE AND EFFECTIVENESS OF TERRORISM-RELATED SIMULATIONS

## TYPES OF TERRORISM-RELATED SIMULATION<sup>3</sup>

There has been very little research into the use or effectiveness of terrorism-related simulations. Eight studies were identified that assessed the effectiveness of specific exercises, only one of which evaluated the impact that a simulation had on a real-life counter-terrorism response.<sup>4</sup> One other study discussed a one-day workshop to create a counter-terrorism training programme.

While evidence on the effectiveness of terrorism-related simulations is limited, the existing literature highlights that a diverse range of exercises has been used to train different types of participant (see table on page 10).

## THE EVIDENCE-BASE INFORMING EXISTING TERRORISM-RELATED SIMULATIONS<sup>5</sup>

The evidence-base informing the development of terrorism-related exercises is often not explicit. Only one study described the process by which a terrorism-related simulation was developed in detail:

‘During a terrorist attack, non-technical skills such as leadership, decision-making and crisis communication refer to the capability to define and organise actions from first responders and then care givers, while “combining good medicine with good tactic” in order to avoid additional casualties’

(Swiech et al., 2020)

- 16 physicians attended a workshop lasting two days. After a two-hour brainstorming session, attendees split into working groups to address predefined themes. After 12 hours, the Task Force gave an intermediate report to an external validation group who provided feedback. The Task Force delivered a final report 12 hours later.
- The final report drew on the French military principle of *Sauvetage au Combat* (combat rescue) to inform the development of a counter-terrorism training programme.
- Their proposed training programme was approved by an ‘external validation group’ and had three phases: 1) online learning; 2) procedural simulation; 3) full-scale terrorism simulation. The aim was to develop both essential technical (i.e. medical) and non-technical skills.

<sup>3</sup> *Aplin and Rogers (2020)* evaluated learning and behavioural outcomes from Project ARGUS training. *Skryabina et al. (2020)* evaluated the impact of Exercise Elsa and Socrates on the response to the Manchester Arena attack of 2017. *Murphy et al. (2020)* evaluated the link between decision-making and procedural skills across six tabletop exercises. *Chittaro and Sioni (2015)* explored the learning outcomes of 44 participants in a trial of their video game simulation. *van den Heuvel et al. (2012)* evaluate the decision-making of participants in a Hydra simulation. *McElroy et al. (2019)* explored the clinical outcomes of a full-scale US-based exercise and identified potential areas of improvement. *Kim (2014)* interviewed 26 participants from three different simulations (two of which were terrorism-related) to identify areas of best practice. *Swiech et al. (2020)* present findings from a 24-hour workshop in which military and non-military physicians developed a counter-terrorism training programme. While it is not clear whether it relates directly to counter-terrorism, *Rüter et al. (2016)* discuss competing approaches to evaluating a disaster preparedness exercise based around a simulated explosion in Stockholm.

<sup>4</sup> Two other relevant Australian studies were identified that were outside the scope of this report. *Vogel and Keibell (2011)* asked members of the public to review a fictional evidence file for a simulated counter-terrorist investigation that was based on a controversial real-life case to explore whether they would reach the same decision as officers in the real case. *Romyn and Keibell (2014)* conducted a ‘red team’ / ‘blue team’ exercise where they asked one team of respondents to play the role of terrorists planning an attack, and another team to decide how best to respond to this potential attack based on how they thought the red team would act. As *Skryabina et al. (2017)* note, a relatively large number of older studies have also discussed simulated bioterrorism attacks.

<sup>5</sup> The development of a specific French counter-terrorism training programme is discussed by *Swiech et al. (2020)*, while *Alison et al. (2012)* describe the design of the Hydra simulation tool originally developed by Crego. *Chittaro and Sioni (2015)* discuss the use of PMT to inform the development of their video game simulation.

## THE CURRENT USE AND EFFECTIVENESS OF TERRORISM-RELATED SIMULATIONS

### Terrorism-Related Simulations

#### *Types of Terrorism-Related Simulation*

*While evidence on the effectiveness of terrorism-related simulations is limited, the existing literature highlights that a diverse range of exercises has been used to train different types of participant*

Study	Simulation/ Exercise	Type of Exercise
Aplin & Rogers (2020) (UK)	Project ARGUS (Participants: Retail workers)	Training session for retail staff built around low fidelity simulation of an attack.
Skryabina et al. (2020) (UK)	Exercise Elsa Exercise Socrates (Participants: Healthcare)	Elsa: A tabletop exercise based on a scenario involving two simultaneous incidents with 400 casualties. Socrates: A one-day field exercise to test the trauma response to a bombing and firearm attack at an airport generating 187 casualties.
Murphy et al. (2020) (Sweden)	Unnamed (Participants: Healthcare)	Six tabletop exercises: Five based on bomb blasts, and one around an active shooter.
Chittaro and Sioni (2015) (Italy)	Unnamed (Participants: Public)	Video game simulation of a terrorist attack on a European railway station.
van den Heuvel et al. (2012) (UK)	Hydra (Participants: Law enforcement)	Team-based computer simulation of a counter-terror investigation and incident.
McElroy et al. (2019) (USA)	Operation Continued Care (Participants: Multi-Agency)	Tabletop exercise and mass-casualty drill based around a simulated terrorist attack at three sites with 445 casualties.
Kim (2014) (UK)	Exercise Saxon Shore Exercise Operation Safe Return (Participants: Multi-Agency)	Saxon Shore: Tabletop and field exercise based around a scenario in which a dirty bomb has been placed on a college campus. Safe Return: Tabletop and field exercise involving explosives on the London Underground.
Rüter et al. (2016) (Sweden)	Emergo Train System (ETS) (Participants: Healthcare)	Tabletop exercise built around a simulated explosion in the centre of Stockholm.
Swiech et al. (2020) (France)	Unnamed (Participants: Healthcare)	Workshop in which physicians developed a counter-terrorism training programme.

- The overall objective of this programme was to 'avoid the occurrence of preventable deaths' by drawing on evidence that found around one-quarter of American combat deaths in Iraq and Afghanistan were considered potentially survivable with access to the right medical treatment.

This study highlights the utility of taking a structured approach to designing simulation-based training programmes. The attendees went through a phased process whereby they identified healthcare professionals who would benefit most from terrorism-related training (non-trauma specialists); identified the specific technical and non-technical skills that they would need, and identified simulation exercises that could be used to build these skills; and identified metrics for assessing the impact of training on these skills. By drawing on existing evidence from the military, they were able to link these skills to the overall objective of the training programme, which was to reduce preventable deaths.

Two studies also highlight how different psychological theories can be used to develop terrorism-related simulations and to link simulation goals to overall life-saving objectives:

- One study outlines the development of the Hydra simulation suite that is used to test a variety of scenarios, including terrorism-related simulations. During Hydra simulations, participants are split into teams and placed into 'syndicate rooms' equipped with a computer, telephone, television and fax machine through which information is relayed to them throughout the scenario. The authors outline how Hydra was informed by naturalistic decision-making (NDM), which dictates that decision-making should be observed in real-time. Hydra uses a series of tools to capture decision-making in-situ, including observation and decision-making logs.
- A video game simulation of a terrorist attack on a train station was developed using Protection Motivation Theory (PMT). PMT argues that individuals will act to protect themselves based on a threat appraisal (when they believe that a threat is severe and that they are vulnerable to it)

and a coping appraisal (when they perceive that recommended actions will be effective and simple to carry out, and when they have high perceptions of self-efficacy). The game is designed to enhance perceptions of severity (through visual and audio stimuli); fear (through visual clues such as blood spatters, or audible sounds of distress); and vulnerability (by making the train station appear similar to those in the country in which the test is taking place), as well as attempting to enhance users' perceptions of self-efficacy.

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### THE IMPACT OF EXISTING TERRORISM-RELATED SIMULATIONS ON LEARNING<sup>6</sup>

Although the evidence-base by which to assess the effectiveness of terrorism-related simulations is limited, the literature highlights that they can have a range of short-term impacts, such as increased knowledge or confidence. Capturing these short-term outcomes is useful for understanding whether the simulation has had any kind of positive effect. However, there are limitations to the use of these metrics:

- They are often based on self-reported attitudinal data, and it is unclear whether increased levels of confidence and/or knowledge will persist in the long-term.
- Post-simulation questionnaires can also be used to capture intended behaviour change, but there is no guarantee that this will translate into actual behaviour change.

The strengths and weaknesses of short-term outcome data, and the importance of conducting follow-up research to compare actual against intended behaviours, are illustrated by one study that draws on interviews with 120 attendees of Project ARGUS simulation-based training sessions:

#### CASE STUDY: THE SHORT-TERM IMPACT OF TERRORISM-RELATED SIMULATIONS

Aplin and Rogers (2020) evaluated the impact of Project ARGUS (Area Reinforcement Gained Using

<sup>6</sup> The evaluation of Project Argus training is presented in *Aplin and Rogers (2020)*. Positive short-term learning outcomes are also discussed by *Chittaro and Sioni (2015)* in their study of a video game simulation.

### Terrorism-Related Simulations

Simulation) training sessions. The training was designed for managers across a range of sectors working in crowded places. Sessions were organised around a low-fidelity terrorist attack simulation. They were designed to deliver learning on what to do in the event of an incident, and to promote longer-term behavioural change whereby business managers would ‘take control in the key early stages [of an attack] and make important decisions that will save and protect lives’.

### Short-term learning outcomes

Based on pre- and post-questionnaires of 120 attendees from the retail sector, this study found that training led to a significant increase in attendees’ self-reported understanding of the role of Counter-Terrorism Security Advisers and the topic of terrorism; ability to deal with the aftermath of an incident; ability to identify / deal with suspicious incidents; and knowledge of business continuity measures.

### Longer-term behavioural outcomes

A survey conducted three-months later with 44 attendees found ‘high percentage indications of implementation of the advice contained in ARGUS’, with 86 per cent having developed an incident management plan, for example. However, 68 per cent reported obstacles to implementing the advice. Follow-up interviews with three participants found that only one had conducted any exercises since their training and that this was ‘more to do with the individual motivation of the manager’.

### Recommendations

Based on the findings of their study, the authors recommend the implementation of a national evaluation programme that assesses the longer-term impact of these training sessions. They also recommend introducing a certification scheme to encourage attendance at sessions and the adoption of advice, and that the government should consider introducing a Protect or Prepare Duty similar to the Prevent Duty.

# THE IMPACT OF EXISTING TERRORISM-RELATED SCENARIOS ON LONGER-TERM PERFORMANCE AND BEHAVIOUR <sup>7</sup>

Longer-term impacts of terrorism-related simulations are poorly understood. Only two studies explore these effects in detail. One study that examined the impact that terrorism-related simulations had on how healthcare professionals responded to the Westminster Bridge, London Bridge, and Manchester Arena attacks in 2017 found 'strong objective evidence that the response to a mass-casualty terrorist incident was enhanced by training and service development achieved' through the use of a simulation (see case study below). These results should be considered alongside the independent inquiry into the response to the Manchester attack, which points to failures in how some agencies responded.<sup>8</sup>

## CASE STUDY: THE IMPACT OF TERRORISM-RELATED SIMULATIONS ON RESPONSES TO REAL-LIFE INCIDENTS

Skryabina et al. (2020) used a mixed-methods approach to study the impact that terrorism-related simulations in London and Manchester had on how healthcare professionals responded to the Westminster Bridge, London Bridge, and Manchester Arena attacks of 2017.

### The simulations

Exercise Elsa was a one-day tabletop exercise that took place on 22nd March 2017 in Manchester. It used a scenario in which two simultaneous incidents resulted in 400 casualties.

Exercise Socrates was a one-day operation-based exercise based around a scenario of a simultaneous suicide bombing and marauding terrorist firearm attack at Manchester Airport that resulted in 187 casualties. It was a hybrid of a command post exercise and a response

drill (see typology above).

Exercise Watling Street was a table-top and operation-based exercise designed to test the South East London Kent and Midway (SELKaM) Emergo Major Trauma Network response to a simulated terrorist incident.

### Evaluation

The authors conducted an online survey between August and December 2017 which interviewed responders to the Westminster Bridge (n=3), Manchester Arena (n=79), and London Bridge (n=4) attacks to evaluate their perceptions of training; the clarity of their own and their colleagues' roles during the response; and their understanding of the major incident plan. In total, 36 participants had taken part in an exercise, almost all of whom (n=33) took part in the Manchester-based exercises (five took part in Elsa only, 20 in Exercise Socrates, and eight in both). Follow-up interviews were then conducted with 21 responders to the Manchester attack. Of these, 13 had attended at least one of the simulation exercises (eight attended Exercise Socrates, one Exercise Elsa, and four attended both).

This study has limitations. Firstly, three-quarters (n=64) of survey respondents worked for NHS Acute Trusts, with only small numbers of respondents working for crucial organisations such as the ambulance service (n=5). Similarly, almost all (n=19) of the follow-up interviews were conducted with those who worked for NHS Acute Trusts, with over half (n=12) conducted with clinical staff.

The results are therefore useful for understanding the impact that simulations had on how victims of these attacks were treated once they reached the hospital, but they say less about other aspects of preparedness which have been criticised by an independent inquiry

<sup>7</sup> The response to the Manchester attack is discussed in *Skryabina et al. (2020)*. The Kerslake report is found *here*.

<sup>8</sup> The ongoing *Independent Inquiry* into the emergency services' response to the Manchester Arena attack has placed great scrutiny on the multi-agency response to this incident. Notably, evidence provided to this inquiry has criticised the emergency services for failing to act to address issues identified in previous terrorism-related simulations, which illustrates that simulations should lead to actionable outcomes where learning is identified.

## RELATED SCENARIOS ON LONGER-TERM PERFORMANCE AND BEHAVIOUR

### Terrorism-Related Simulations

into the response to the Manchester attack, such as coordination between agencies, or response times of ambulance services. Secondly, the results are based on self-reported data from interviews and surveys. While insightful, this does not provide objective evidence of the simulation building preparedness. However, this study still provides an excellent insight into how lessons learned from simulations apply to real-life incidents.

caveat is that the attack occurred only weeks after Exercise Socrates, so it is unclear whether effects would be sustained over the longer-term.

### Results

The quantitative survey found that responders who had attended a simulation exercise reported that they had been ‘significantly better prepared’ when responding to the incident, although this was the only significant difference between those who had attended a simulation and those who had not. Five of the 13 respondents who had attended the Exercise Elsa tabletop exercise and 24 of the 28 respondents who had participated in Exercise Socrates explicitly stated this had made a difference to their ability to respond. Comparative findings for Exercise Watling Street are not discussed in the paper.

In the follow-up interviews, the vast majority of the 13 responders to the Manchester attack who had attended a simulation exercise also reported benefits from participating in these exercises, including having an opportunity to practice their response prior to the real incident (11 respondents); giving them confidence in knowing what to do (10 respondents) and in the incident management plan that had been tested as part of Exercise Socrates (eight respondents); and giving them the confidence to introduce dynamic changes to existing practices on the night ‘that proved to be effective and saved lives’ (seven respondents). Given the small sample size, and the lack of clarity in how the sample for the follow-up interviews was selected, these results should not be considered generalisable.

### Conclusions

The exercises had both individual (e.g. confidence, clarity of roles etc.) and systemic benefits (i.e. the opportunity to practice and to develop a workable incident plan) which facilitated the overall response to the Manchester attack. This finding was supported by the official review into the response to this incident (The Kerslake Report), in which staff groups from six hospitals reported that Exercise Socrates had prepared them well for this incident. However, an important

# USING TERRORISM-RELATED SIMULATIONS TO EVALUATE PERFORMANCE <sup>9</sup>

There is no single method for evaluating performance in simulations. One study highlighted the utility of using two different methods to evaluate the impact of two tabletop exercises that tested the medical response to an explosion in Stockholm. The first model was the Hospital Incident Command System (HICS) model, which uses a standardised set of outcome metrics to assess the performance of management functions during a response. The second model was the more process-orientated Disaster Management Indicator model (DiMI) which records whether key decisions were made, but not the effect of the decision, which can only be captured through an additional stage of interviews.

- The HICS records whether positions, such as public communication or incident command, are activated in the wake of an incident. It evaluates the performance of each activated position using job action sheets that outline actions that need to be taken by responders in charge of different positions. Each position receives an overall performance score, which is a percentage based on the accuracy of the actions taken. The hospital is awarded an overall performance score based on the average percentage score of each incorporated position.<sup>10</sup>
- The DiMI model consists of two groups of indicators: hospital management and staff skills. Each has 11 indicators which are scored as correct (2), partly correct (1), or incorrect/omitted (0).
- The authors argue that the HICS model was better able to capture structural factors (i.e. staff skills) than the DiMI model. However, they also note that the two models produced somewhat contradictory results (owing to their different focus), as according to HICS, overall performance was higher for the

first exercise, while DiMI gave better scores to the second.

- Therefore, they conclude that there is no single performance metric on which to evaluate response preparedness and suggest that these two models might complement each other.

The DiMI model has illustrated the importance of proactive decision-making when responding to critical incidents.<sup>11</sup> In a second study, this model was used to evaluate the performance of healthcare responders across six terrorism-related tabletop exercises:

- The authors compared performance scores on 11 indicators relating to staff decision-making skills (e.g. estimating the needs of the intensive care unit; providing the first information to the media) and scores on 11 indicators relating to procedural skills (e.g. assigning functions to individual staff members; utilising equipment).
- When dividing the decision-making indicators into six reactive (i.e. reflexive decisions based on previous experiences that require little cognitive time) and five proactive (i.e. more time-consuming decisions) decisions, the authors found that those with lower proactive decision-making skills had statistically significant lower performance scores.
- The study concludes that 'proactive decision-making skills, in particular, may therefore have an impact on overall disaster performance'.

Performance during terrorism-related simulations can be evaluated using different metrics. For example, in the two case studies below, one study evaluated performance against a set of outcome measures and used the exercise to identify crucial areas of improvement, while the other used a simulation to assess the process of decision-making, and the decisions taken by

<sup>9</sup> *Ritter et al. (2016)* discuss competing evaluation approaches. Case studies are drawn from *McElroy et al. (2019)* and *van den Heuvel et al. (2012)*. The exercise to test the utility of wearable technology in disaster response is discussed in *Alharthi et al. (2018)*.

<sup>10</sup> For more information on the HICS model, see *California Emergency Medical Services Authority (2014)*.

<sup>11</sup> Based on an analysis of responders' performance across six tabletop exercises (*Murphy et al., 2020*).

## USING TERRORISM-RELATED SIMULATIONS TO EVALUATE PERFORMANCE

### Terrorism-Related Simulations

participants.

No studies were identified that evaluated the impact of terrorism-related simulations on casualty projections. However, while the evidence is only anecdotal, several clinicians who participated in Exercise Socrates felt that the lessons that they had learned from this simulation had saved lives during the Manchester Arena attack. Specific life-saving lessons cited by those who treated patients once they arrived at the hospital included:

- The use of a one-way flow system for treating parents and children which ‘had not even been considered’ before the simulation
- Altering decision-making about who should be sent to surgery so as to leave space for head injuries to be treated immediately
- A more efficient approach to delivering blood transfusions.

### CASE STUDY: USING SIMULATIONS TO ASSESS RESPONSE EFFECTIVENESS

I’ll just point to the transfusion as being a really hot solution that came out of a challenging exercise issue that then paid massive dividends on the night.

(Exercise Socrates participant interviewed by Skryabina et al., 2020)

*McElroy et al. (2019) highlight how existing information management systems and quantitative metrics can be used to evaluate response effectiveness, and key treatment-related outcomes.*

The authors evaluated the performance of participants in a multi-agency counter-terrorism drill that involved four law enforcement agencies, five fire and emergency medical services departments, and 16 supporting organisations. This simulation was organised around a scenario in which three separate incidents had produced 445 casualties and was preceded by a tabletop exercise.

This simulation had seven strategic objectives, with the research team assessing the overall achievement of each objective using a three-point scale: performed with some challenges (S); performed with major challenges

(M); or unable to be performed (U):

1. Effective operational coordination
2. Sustained two-way communication
3. The effective use of relevant information management systems during the incident
4. Participants requesting resources in accordance with plans, policies, and procedures
5. Responders effectively triaging patients
6. Hospitals effectively tracking patients
7. Hospitals inputting victims into relevant information management systems.

### Results

All objectives received a score of ‘S’ which meant that they were achieved with ‘some challenges’. Overall, all critical tasks ‘were completed in a manner that achieved the objective and did not negatively affect the performance of other activities’:

- 270 out of 445 patients (60%) were entered correctly into the state patient tracking system
- The severity of 102 patients’ injuries was either over or under-assessed at the event site
- Multiple opportunities for improvement were identified, including improving coordination and communication between regional bodies and hospitals and incident sites.

### CASE STUDY: USING SIMULATIONS TO ASSESS COUNTER-TERRORISM DECISION-MAKING

*van den Heuvel et al. (2012) highlight how simulations can be used to explore how and why responders make decisions, and to identify factors that might undermine optimal decision-making.*

The authors analysed the decision-making of 136 category 1 responders who attended a one-day counter-terrorism simulation. Participants were split into 17 teams and given intelligence on three individuals who



had been charged with a terrorism offence and who were due to go to court. They also received information on three events: 1) a Labour convention held on the day of the simulation; 2) a military parade planned for two days' time; and 3) a planned protest by an animal welfare group.

Throughout the day, new intelligence emerged: three people arriving in the UK after receiving weapons training in Afghanistan; two rifles being removed from a weapons cache; shots being fired at the convention; confirmation that one of the three arrivals from Afghanistan was responsible; and links between the perpetrator(s) and a group in a different county.

### Evaluating decision-making

Researchers analysed decision-making logs and observed teams to map decision-making against a linear model of decision-making, SAFE-T: Situation Assessment (SA), Plan Formulation (F), Plan Execution (E), and Team Learning (T).

Decisions were evaluated against a 'gold standard'. Five experts were given all of the intelligence and asked to make three decisions: 1) when to declare a critical incident; 2) whether to cancel the parade; 3) whether this force should retain primacy over the incident given the links to a group in another county. Participants' decision-making was analysed based on a) whether they made a definitive decision on these three points; and b) whether they made any decisions earlier or later than the experts would have done.

### Results

Teams did not follow the decision-making model, and often skipped steps or made decisions in reverse order. Optimal decision-making was often derailed by a combination of making decisions too late; making a decision based on an overemphasis on public confidence; or by avoiding a decision completely.

# LEARNING FROM OTHER FIELDS: KEY PRINCIPLES IN DESIGNING AND EVALUATING SIMULATIONS

While the evidence base relating to terrorism-related simulations discussed above is limited, lessons can be drawn from the broader literature on simulation-based training. This section draws on this literature to outline key features to consider when designing and evaluating simulation exercises.

## KEY PRINCIPLES IN DESIGNING TRAINING PROGRAMMES WITH A SIMULATION COMPONENT <sup>12</sup>

Several studies have outlined the key principles to consider when designing training programmes for emergency responders. While these studies do not explicitly discuss training relative to terrorist incidents, key design lessons can be learned from this broader literature.

Operation-based exercises are often based on a ‘building block’ approach where training programmes start with more basic discussion-based exercises and progress towards different forms of operation-based exercises which incorporate increasing levels of complexity, culminating in full-scale exercises that require the most time and resources to plan and deliver. Response plans should only be fully tested through operation-based exercises when they are developed enough for feedback to be valuable.

The decision over when to use specific types of simulation should be informed by a clear understanding of which type of exercise is most appropriate for delivering desired outcomes. For example, it may be useful to test or validate fully formed counter-terrorism procedures, and to design a scenario that specifically

evaluates the response to a simulated terrorist incident. However, if the objective is to build broader functional, managerial, or adaptability capabilities amongst responders, smaller-scale exercises that are not related to terrorism could also be used to prepare responders for terrorist incidents by building broader capabilities that are applicable outside of the scenario being simulated:

- One study reported that the ability to practice and develop collaboration skills was a strong predictor of how useful simulation-based exercises were seen to be by 94 members of the Swedish police, fire, and ambulance services who had participated in different simulated scenarios. While 84 per cent said the exercise had been useful for real-life work, the authors noted that the correlation between perceived usefulness and perceptions that the exercise had relied on collaboration was greater than the relationship between perceived usefulness and learning outcomes, such as learning something new or learning about organisational processes.
- In a different study, the authors developed a framework for designing scenarios to effectively test specific capabilities: 1) select the capabilities to be tested; 2) select exercise components that will specifically test each capability; 3) create a scenario incorporating these components; and 4) compile ways of measuring and evaluating capability execution.

## KEY PRINCIPLES IN DESIGNING SIMULATIONS <sup>13</sup>

While simulation-based training exercises are perceived to have positive impacts on learning and

<sup>12</sup> The importance of adopting a building block approach is discussed by studies including *Kim (2014)* and a guide written by the *WHO (2017)*. The framework for testing capabilities-based exercises is drawn from *Greenberg et al. (2017)*, and the study of 94 Swedish first responders was conducted by *Berlin and Carlström (2015)*.

<sup>13</sup> Barriers to effectiveness are discussed by *Berlin and Carlström (2015)* in their exploration of the experiences of 94 participants in three exercises in Sweden. Best-practice principles are discussed by *Alharthi et al. (2018)* based on previous evaluations the authors had conducted; *Alison et al. (2012)* drawing on their experiences of evaluating simulations and a literature review; and *Kim (2014)* based on interviews with 26 participants in three simulations. For a comprehensive overview of design principles for different types of exercise, see *WHO (2017)*.

## KEY PRINCIPLES IN DESIGNING AND EVALUATING SIMULATIONS

Knowledge Management Across the Four Counter-Terrorism 'Ps'

behaviour, research points to some issues that can limit their effectiveness for training participants about how to respond to a range of mass-casualty incidents, including terrorist attacks:

- Exercises may have different and competing objectives. For example, there may be a conflict between learning about existing procedures and learning how to adapt to circumstances
- It can be difficult to evaluate how different parts of complex scenarios fit together, and how individual elements of complex scenarios contribute to the specific objectives of the exercise

- Participants in multi-agency exercises may set their own organisational objectives and focus on their own tasks rather than see the 'big picture'. For example, participants may be comfortable doing the tasks that come naturally in their day-to-day work but may be unable or unwilling to consider how these tasks affect and intersect with the work of other agencies.

Several studies have identified areas of good practice to inform the design of simulation-based training exercises, including terrorism-related simulations. Some of the examples in the table below are based on specific programmes, while others are based on literature reviews designed to inform future practice.

<b>Principles of Good Simulation Design</b>		
<b>Alharthi et al. (2018) Review of good design practice for all disaster simulations</b>	<b>Alison et al. (2012) Review of good practice for all disaster simulations alongside a Hydra case study</b>	<b>Kim (2014) Review of good practice for all disaster simulations with specific focus on counter-terrorism</b>
<p><b>Communication modalities</b></p> <p>Participants should be both co-located and separately located so that they have to communicate with each other and coordinate their work in different ways throughout the exercise.</p> <p><b>Uncertain information</b></p> <p>Provide participants with different information so that integration and collaboration are needed.</p> <p><b>Enhance situation awareness</b></p> <p>Use audible clues to supply information in order to build situational awareness.</p> <p><b>Engage developing intelligence</b></p> <p>Require participants to make informed decisions about how to collect and judge information.</p> <p><b>Create emergent objectives</b></p> <p>Objectives should be dynamic so that participants have to adapt.</p> <p><b>Support collaborative planning</b></p> <p>Include diverging and converging activities for different participants.</p>	<p>Use experts in the design and implementation of simulations.</p> <p>Ensure psychological fidelity by including the below in exercises:</p> <ul style="list-style-type: none"> <li>• Complexity: Provide a realistic set of features or goals, including pressures of accountability that can influence decisions.</li> <li>• Dynamicity: Develop scenarios that evolve with decisions.</li> <li>• Opaqueness: Make some information inaccessible so participants have to rely on their previous experience(s) and on collaboration with other actors.</li> </ul> <p>Measure social and cognitive processes in real-time using observational methods.</p>	<p>Build adaptability and flexibility into the scenario to test capabilities.</p> <p>Adopt a building block approach so that operation-based exercises are preceded by and can build on discussion-based exercises.</p> <p>Allow citizens to participate in simulations / exercises, and to feedback on performance.</p> <p>Use discussion-based debriefing sessions to enhance learning.</p>

## KEY PRINCIPLES IN DESIGNING AND EVALUATING SIMULATIONS

### Terrorism-Related Simulations

The reviews of good simulation design practice above do not always explicitly discuss terrorism-related simulations. However, key design lessons can be learned from this broader literature.<sup>14</sup>

The fidelity, or the level of similarity between a simulation and the real world, is important. One study of healthcare preparedness exercises identified three key features of fidelity: casualties must act in the way that they would in real life and their injuries must be realistic; the equipment and resources available to responders must match what is available in real-life; and the scenario itself must be realistic, in that responders are given autonomy to act in the way that they would in a real-life incident.

‘Psychological fidelity’ or recreating emotional and cognitive responses incited by a real-life incident, is more important than physical fidelity or accurately recreating the physical features of a real-life response. Several authors have outlined the potential benefits of using technological solutions such as virtual reality to enhance physical fidelity, but there has yet to be a robust evaluation of the effectiveness of such solutions compared to more traditional simulations. Simulations should recreate the complexity, dynamicity, and opaqueness of responding to real-life terrorist incidents, and the processes through which individuals interact with each other and their environment in these circumstances.

Several studies outline the different stages of simulations. For example, one review of existing approaches noted that scenarios should be made up of three different components, each of which should be linked to particular capabilities to make clear how these skills are tested, and how they can be evaluated:

- Baseline event: the event around which the simulation is constructed
- Baseline tasks: specific activities that need to be undertaken

- Introduction of complexity factors, such as dealing with the unexpected, dealing with scale and time, organising and managing people etc.

A good example of a staged design is the Hydra simulation protocol, which, as discussed earlier, has been used to simulate a range of different scenarios, including counter-terrorism exercises. Hydra simulations focus on team dynamics and incorporate a range of complexity factors that both ‘recreate the internal uncertainties’ of responding to critical incidents, as well as the ‘external pressures of accountability’, and they require participants to use both technical and non-technical skills. They incorporate plenary sessions that provide opportunities for reflective learning and allow feedback to inform decision-making later in the simulation. The exercises conclude with a debrief – a session in which all participants share feedback on their experiences and learning from the simulation.

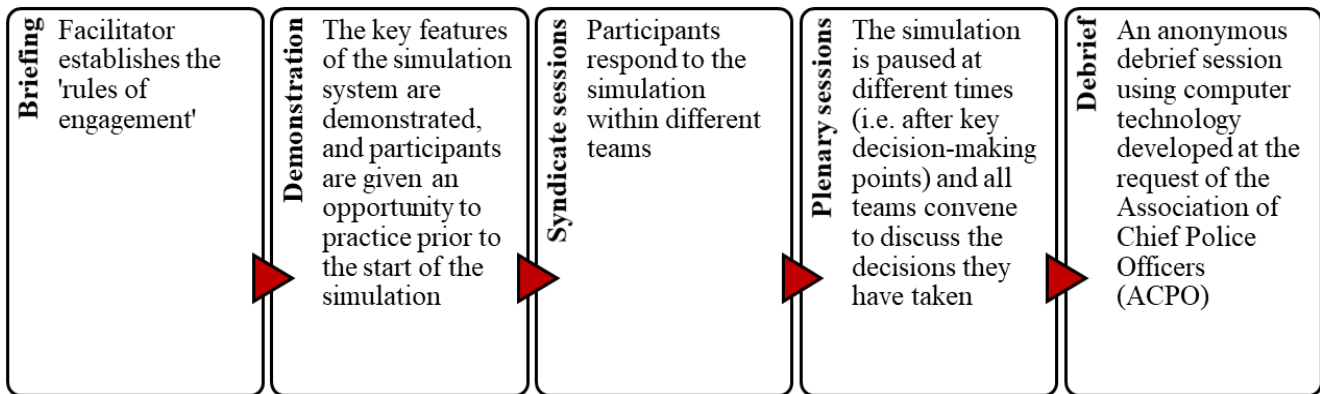
A related benefit of the Hydra simulation is that they provide opportunities for collecting a huge amount of data from the simulation throughout the syndicate sessions; plenary sessions; and the final debrief.

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14 Fidelity in healthcare scenarios is discussed by *Tun et al. (2015)*, and the importance of psychological fidelity is discussed by *Alison et al. (2012)*. The latter study discusses the five phases of Hydra simulations. *Greenberg et al. (2017)* discuss three different components to a simulation exercise. The importance of debriefs is discussed by several studies including *Allen et al. (2018)*, *Kessler et al. (2015)* and *Tannenbaum and Cerasoli (2013)*. The performance impact of debriefs is discussed in the latter study. *Alharthi et al. (2018)* discuss the current state of technological solutions to delivering simulations but note that ‘the results of such training are often insignificant’.

## CASE STUDY:

## HYDRA – A STAGED APPROACH TO SIMULATION (ALISON ET AL., 2012)



Debriefing sessions are crucial for enhancing learning. One review analysed 46 samples of participants who had attended simulation exercises across 31 existing studies (n=2,136).

While this did not focus on terrorism-related scenarios, an analysis of quantitative performance indicators from each study (e.g. simulator reports, game scores, hospital records, self-ratings, performance ratings etc.) found that, on average, debriefs improved the effectiveness of individuals who had participated in a simulation compared to a control group by approximately 25 per cent.

It also found that facilitated debriefs (27% increase in performance) were three times more effective than non-facilitated debriefs (10% increase).

# KEY PRINCIPLES IN EVALUATING SIMULATIONS AND EXERCISES <sup>15</sup>

Evaluations of simulations can serve several purposes, including to support the direction of and investment in future learning; provide insights into the efficiency and performance of current practice; and enhance individual / organisational learning and accountability.

Evaluation is therefore a crucial part of simulation-based training. However, several studies have commented on the absence of robust evaluation and assessment of the longer-term effects of simulation-based training exercises more broadly, not just those related to terrorism. For example, one review of 43 evaluation reports found that they often lacked clarity around important details:

1. The purpose and context in which specific evaluation methods are to be used
2. What the evaluation method needs to do to fulfil its purpose
3. How the method achieves its goal and thereby fulfils its purpose.

If an evaluation report is to have a longer-term impact on practice, its findings must be usable. Drawing on interviews with 84 mayors and crisis management professionals, one study argues that a usable evaluation has a clear purpose, object, analysis and conclusion, and finds that the clarity of analysis and conclusion had a significant impact on learning outcomes for these key decision-makers.

Evaluation data can be collected pre-exercise, post-exercise, or during the exercise using different qualitative and quantitative methods and analysis tools. The most common method of evaluating performance is interviewing participants pre- and post-simulations to assess the impact of a simulation on knowledge,

Evaluation is an important aspect of these exercises. Whatever the style or level of exercise, a well-constructed evaluation process is the key to providing evidence-based feedback on performance. It supports the direction of, and investment in, future learning and development.

(Beerens & Tehler, 2016)

confidence and competence. Examples of data collection tools in the literature include: (see table on page 23).

Collecting data during exercises can be particularly useful for assessing how participants engage with their environment and with each other. This can be through technological solutions such as audio and video recording or the use of sensors, or through in-person observation and the use of decision-logs.

It is crucial that data collection tools are appropriate for the metrics being tested, and that these metrics are well matched to simulation objectives. One study outlines a typology of different outcomes:

1. Reactions (satisfaction with training)
2. Learning (skills and/or knowledge learned)
3. Behaviour (what changes in behaviour have occurred)
4. Results (what impact the simulation had on outputs of the system)

An example of a particularly strong mixed-methods approach is shown on page 24. Its strengths are that it draws on a variety of different data collection methods to triangulate evidence (i.e. corroborating different findings across different quantitative and qualitative

15 Objectives of evaluations are drawn from an analysis conducted by *Beerens et al. (2020)*. This study also discusses the utility of evaluation reports as seen by mayors and crisis management professionals. The review of 43 evaluation reports was conducted by *Beerens and Tehler (2016)*. Data collection tools are drawn from a review of different studies, but the discussion of expert interviews and data collection during exercises is drawn from *Alison et al.'s (2012)* overview of Hydra simulations; the use of sensors from *Chittaro and Sioni (2015)*; and the strengths and weaknesses of hot and cold debriefs from *Kessler et al. (2015)*. The typology of different evaluation outcomes is drawn from *Skryabina et al. (2020)*. The case study is from *Waring's (2019)* evaluation of a simulated train derailment. This study also discusses ways to improve the trustworthiness of evaluation findings.

## KEY PRINCIPLES IN EVALUATING SIMULATIONS AND EXERCISES

Knowledge Management Across the Four Counter-Terrorism 'Ps'

Stage	Method	Strengths and Weaknesses
Pre-Exercise	Quantitative surveys or qualitative interviews to assess baseline confidence, competence or knowledge.	Important for establishing a baseline of key technical and nontechnical skills against which to assess learning outcomes of simulations. Baseline is often based on self-reported data which lacks the objectivity of formal testing, which may be impractical to administer.
	Qualitative interviews with subject matter experts to understand what optimal response looks like.	Useful for establishing what an optimal response would look like when the uncertainty and pressures of the simulation are removed. Expert opinions can be subjective, and experts may disagree about what an optimal response would look like.
	Qualitative interviews with experts to identify key elements to be analysed during and post-exercise.	Enables the researcher to develop a greater understanding of the key processes that influence how teams respond to incidents, and to identify indicators by which to assess performance during the simulation. Suffers from the same issue of subjectivity as noted above.
	Analysis of current performance based on metrics in information management systems	Useful for determining baseline performance on key metrics. Relevant information systems only exist in certain settings (e.g. hospitals) and only record limited information, which will likely need to be contextualised with in-depth interview and/or survey data.
During Exercise	Observation of teams in-person or through CCTV.	Important for observing decision-making in situ, and for identifying challenges and solutions that emerge when responding to incidents. They are unable to capture all cognitive processes, while the data collected might be shaped by the researchers' own interpretations.
	Structured observations of decisions using decision-making logs that are completed by participants.	Useful for recording decision-making in real time. Also ensures consistency in data collection and provides an audit trail so that other researchers can potentially replicate the approach to verify findings. Outcomes do not capture the full range of different social and cognitive processes that might have contributed to decisions.
	In-depth transcription of communication logs.	Provides an opportunity for in-depth analysis of when and how inter-team processes manifest and ensures a greater completeness of data. Depending on the method of transcription used, transcripts may not capture important forms of non-verbal communication.
	Use of sensors to collect physiological information, such as levels of stress.	Useful for capturing psychological and emotional responses to incidents, and in turn how emotions shape decisions. May be impractical and can reduce the fidelity of the simulation by asking participants to wear technology they would not use in real life.
Post-Exercise	Debrief sessions held either immediately following the end of simulation ('hot') or at a later date ('cold').	Benefits of hot debriefs are that all participants can be easily included; they provide an opportunity to reflect while the experience is fresh and any pressing issues can immediately be addressed. They often face time constraints. Cold debriefs provide the chance to reflect on longer-term impacts and for participants to share perceptions having had time to reflect on their experiences. It can be difficult to reassemble participants, who might also struggle to recall the specifics of their experience.
	Post-simulation surveys or qualitative interviews to compare to baseline.	Useful for comparing short-term outcomes of the simulation against baseline measures. Depending on sample sizes and sampling strategies there are issues relating to objectivity and generalisability.
	Analysis of performance metrics from relevant information systems.	Useful for comparing key metrics versus baseline metrics. The type and detail of the information will likely be limited.

# KEY PRINCIPLES IN EVALUATING SIMULATIONS AND EXERCISES

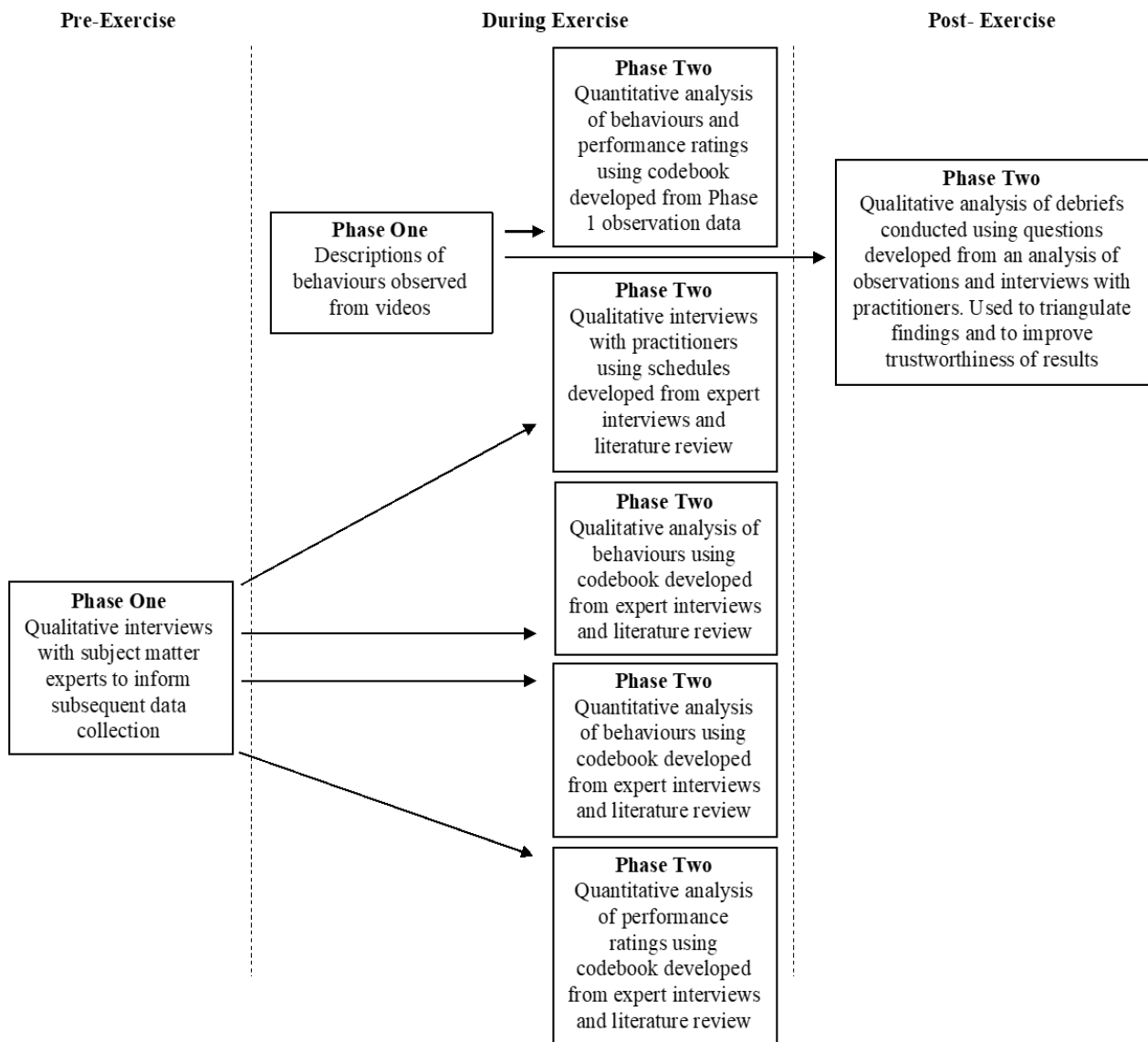
## Terrorism-Related Simulations

methods, and drawing on interviews with both experts and practitioners), and uses a multi-stage approach to collecting data that captures not only the processes of decision-making and the performance of participants but also key learning outcomes as identified in debrief sessions.

Crucially, the arrows in the diagram illustrate how the different stages of data collection build on each other so that the data collected at each stage directly addressed key elements of disaster response that were identified during earlier stages of data collection.

### CASE STUDY:

#### A MIXED-METHODS APPROACH TO EVALUATING SIMULATIONS (WARING, 2019)





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# COMMENTS ON THE EVIDENCE BASE

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The evidence-base on the use and effectiveness of terrorism-related simulations is limited. More in-depth research is needed to understand the specific objectives of individual simulations, and the effect that different simulations have on longer-term learning, behaviour and performance. Where possible, evaluators should consider using longitudinal data collection methods that track impacts over time.

Much of the literature on simulation-based learning, and the principles of designing and evaluating such exercises, is exploratory. While this report has presented an overview of good practice, more research is needed to explore the impact that different features of simulations have on effectiveness.

Research into multi-agency simulations is lacking. Most studies focus on the response of specific agencies or fail to explore the dynamics between different agencies in any detail. As responding to terrorist incidents requires a multi-agency approach, more research into how terrorism-related simulations impact on coordination and collaboration between different responders is needed.

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