

## Appendix 1

### Search terms

Emergency situations: 'disaster'; 'natural disaster'; 'weapons of mass destruction'; 'bioterrorism'; 'chemical, biological, radiological, nuclear'; 'CBRN'; 'Terror\*'; 'Explosions'; 'mass casualty'; 'pandemic'; 'emergency preparedness'; 'crisis management'; 'emergency response'; 'major incident'.

Types of emergency exercises: 'emergency preparedness training'; 'emergency preparedness exercises'; 'table\*top'; 'tabletop'; 'desktop'; 'emergo train system'; 'ETS'; 'Emergo'; 'operation-based exercise'; 'drill'; 'functional exercise'; 'simulation exercise'; 'simulation'; 'mass casualty training system'; 'MACSIM'; 'live casual\*'; '\*mannequin\*'; 'whiteboard\*'; 'puppets'; 'gerbers'; 'board-game'; 'full\*scale exercise'; 'full\*scale field exercise'; 'live exercise'; 'major live exercise'; 'major exercise'; 'major incident training'.

## Appendix 2

### Exclusion criteria

- (I) Share experience of developing and conducting emergency exercises (no outcomes reported);
- (II) Student emergency training course/programme in emergency medicine or training;
- (III) Exercises duration longer than 7 days;
- (IV) Specific departmental training in emergency medicine (clinical emergency situation);
- (V) Reports of dealing with emergency situations/treatment of mass casualties;
- (VI) Test specific equipment used in emergency;
- (VII) Emergency preparedness survey;
- (VIII) Emergency planning/policy/development/building knowledge/discuss of issues to consider to improve emergency preparedness (not related to exercise);
- (IX) Long-distance learning (not face to face);
- (X) Develop evaluation tools (e.g., quantitative performance indicators);
- (XI) Evaluate emergency preparedness curriculum;
- (XII) Different teaching methods in emergency medicine;
- (XIII) Articles not related to "human";
- (XIV) Articles with no mention of health input;
- (XV) Pure discussion-based exercises, e.g., seminars, tabletop exercise (TTX);
- (XVI) Conference proceedings/abstracts/short reports.

## Appendix 3

### ETS: design (n=7)

Author [year] (ref.)	Country	Purpose	Scope: geographical	Scope: functional	Scope: organisational	Scope: administrative	Threat	Fidelity: environmental	Fidelity: physical	Fidelity: functional
Ashkenazi <i>et al.</i> [2012] (42)	Israel	Improve methods	Country	Hospital casualty management	Multiple Hospital	Operational	Mass casualty	<i>In-situ</i>	Puppets/ Gerbers	Real-time Time-pressure
Franc-Law <i>et al.</i> [2008] (12)	Canada	Improve methods	Single site	Hospital casualty management	Single hospital	Operational Strategic	Mass casualty	–	Puppets/ Gerbers	Real-time
Idrose <i>et al.</i> [2007] (46)	Malaysia	Improve methods	Single site	Hospital casualty management Pre-hospital casualty management	Multiple agencies	Operational	Mass casualty	Whiteboards	Puppets/ Gerbers	–
Lenquist Montán <i>et al.</i> [2017] (40)	Sweden	Improve preparedness	Single site	Hospital casualty management Pre-hospital casualty management	Single hospital	Operational Strategic	Mass casualty	Whiteboards	Puppets/ Gerbers	Real-time Time-pressure
Nilsson <i>et al.</i> [2013] (41)	Sweden	Improve methods	Country	Hospital casualty management Pre-hospital casualty management	Multiple agencies	Operational Strategic	Mass casualty	Whiteboards	Puppets/ Gerbers	Real-time
Riley <i>et al.</i> [2012] (a) (39)	UK	Improve methods	City	Hospital casualty management	Multiple hospitals	Operational Tactical Strategic	Mass casualty	Whiteboards	Puppets/ Gerbers	Real-time
Riley <i>et al.</i> [2012] (b) (39)	UK	Improve methods	Regional	Hospital casualty management	Multiple agencies	Operational	Mass casualty	Whiteboards <i>In-situ</i>	Puppets/ Gerbers Moulaged casualties	Real-time

(a) and (b) refer to the same study (39), where two different types of exercises are discussed. ETS, Emergo Train System; ref., reference.

*ETS: outcomes (n=7)*

Author [year] (ref.)	Plans/protocols	Clinical skills	Resources	Communication
Ashkenazi <i>et al.</i> [2012] (42)	Identify gaps/issues	–	Management	–
Franc-Law <i>et al.</i> [2008] (12)	–	Triage	Management	–
Idrose <i>et al.</i> [2007] (46)	Identify gaps/issues	–	–	–
	Adherence			
Lenquist Montán <i>et al.</i> [2017] (40)	Identify gaps/issues	–	Availability Management	–
Nilsson <i>et al.</i> [2013] (41)	Identify gaps/issues	Triage	Management	Inter-agency
Riley <i>et al.</i> [2012] (a) (39)	–	–	Availability Equipment issues	–
Riley <i>et al.</i> [2012] (b) (39)	–	–	Management	Efficiency/quality

(a) and (b) refer to the same study (39), where two different types of exercises are discussed. ETS, Emergo Train System; ref., reference.

FSX: design (n=7)

Author [year] (ref.)	Country	Purpose	Scope: geographical	Scope: functional	Scope: organisational	Scope: administrative	Threat	Fidelity: environmental	Fidelity: physical	Fidelity: functional
Crandall <i>et al.</i> [2004] (16)	USA	Improve preparedness	Regional	Outbreak surveillance	Multi-agency	Operational Tactical Strategic	CBRN	<i>In-situ</i> Simulated incident command	Moulaged actor/casualties	Real-time Time pressure
Eastwood <i>et al.</i> [2010] (44)	Australia	Improve preparedness	Regional	Outbreak surveillance	Multiple hospital	Operational Tactical Strategic	Infectious disease	<i>In-situ</i> Simulated incident site Simulated incident command	Moulaged actor/casualties	Real-time Time pressure
Klima <i>et al.</i> [2012] (22)	USA	Improve methods	Regional	Pre-hospital casualty management Hospital casualty management	Multiple hospital	Operational Strategic	Infectious disease	<i>In-situ</i> Simulated incident command	Moulaged actor/casualties Real medical/decontamination tools Real communication tools	Real-time Time pressure
McElroy <i>et al.</i> [2019] (25)	USA	Test preparedness	Regional	Pre-hospital casualty management Hospital casualty management	Multi-agency	Operational Strategic	Mass casualty	<i>In-situ</i> Simulated incident site	Moulaged actor/casualties	Real-time Time pressure
Petinaux <i>et al.</i> [2017] (28)	USA	Improve preparedness	Regional	Hospital casualty management	Multiple hospital	Operational Strategic	Mass casualty	<i>In-situ</i> Simulated incident command	Moulaged actor/casualties Real communication tools	Real-time Time pressure Media pressure
Stone <i>et al.</i> [2018] (31)	USA	Improve preparedness	Regional	Outbreak surveillance	Multi-agency	Operational Strategic	CBRN	<i>In-situ</i>	Moulaged actor/casualties Real communication tools Real transport	Real-time Time pressure Behavioural challenges Media pressure
Tyre [2001] (32)	USA	Test preparedness	Regional	Pre-hospital casualty management Hospital casualty management	Multi-agency	Operational Strategic	CBRN	<i>In-situ</i> Simulated incident command Simulated incident site	Moulaged actor/casualties	Real-time Time pressure Media pressure

FSX, full-scale exercise; ref., reference; CBRN, chemical, biological, radiological, or nuclear.

*FSX: outcomes (n=7)*

Author [year] (ref.)	Plans/protocols	Clinical skills	Decontamination	Resources	Communication
Crandall <i>et al.</i> [2004] (16)	–	Triage	–	–	Improvements
Eastwood <i>et al.</i> [2010] (44)	Identify gaps/issues Modifications	Infection control procedure	–	Availability	Technology use
Klima <i>et al.</i> [2012] (22)	Identify gaps/issues	–	Protocols/procedures Containment Casualty management	Management	Efficiency/quality
McElroy <i>et al.</i> [2019] (25)	–	–	–	Management	Technology use
Petinaux <i>et al.</i> [2017] (28)	Identify gaps/issues	Triage	–	–	Improvements
Stone <i>et al.</i> [2018] (31)	Identify gaps/issues	–	–	Availability	Efficiency/quality
Tyre [2001] (32)	Modifications	Triage	Protocols/procedures Containment Casualty management	Availability	Efficiency/quality

FSX, full-scale exercise; ref., reference.

*FX: design (n=13)*

Author [year] (ref.)	Country	Purpose	Scope: geographical	Scope: functional	Scope: organisational	Scope: administrative	Threat	Fidelity: environmental	Fidelity: physical	Fidelity: functional
Denny <i>et al.</i> [2005] (17)	USA	Test preparedness	Regional	Outbreak surveillance/ response	Multi agency	Operational  Strategic	CBRN	<i>In-situ</i>  Simulated incident command	Moulaged actors/ casualties  Real medical/ decontamination tools	Real-time  Time pressure Media pressure
Djalali <i>et al.</i> [2014] (48)	Italy	Improve methods	Regional	Hospital casualty management	Single hospital	Operational Strategic	Mass casualty	Simulated incident command	Moulaged actors/ casualties	Real-time Time pressure Media pressure
Edwards <i>et al.</i> [2006] (45)	Australia	Improve preparedness	Single site	Pre-hospital casualty management	Multi agency	Operational	CBRN	<i>In-situ</i>  Simulated incident site	Moulaged actors/ casualties  Real medical/ decontamination tools	Real-time  Time pressure Behavioural challenges
Fitzgerald <i>et al.</i> [2003] (18)	USA	Improve preparedness	City	Pre-hospital casualty management	Multi agency	Operational  Strategic	CBRN	Simulated incident site	Moulaged actors/ casualties  Real medical/ decontamination tools Real transport	Real-time  Time pressure
Haverkort <i>et al.</i> [2016] (49)	Netherlands	Improve methods	Single site	Hospital casualty management	Single hospital	Operational  Tactical Strategic	Mass casualty	<i>In-situ</i>  Simulated incident command	Moulaged actors/ casualties  Real communication tools	Real-time  Time pressure
Hoffman and Norton [2000] (19)	USA	Test preparedness	Regional	Hospital casualty management  Outbreak surveillance/ response	Multi agency	Operational  Strategic	CBRN	<i>In-situ</i>  Simulated incident command	Moulaged actors/ casualties  Real medical/ decontamination tools Real communication tools	Real-time  Time pressure Media pressure
Kohlhoff <i>et al.</i> [2012] (23)	USA	Test preparedness	Borough	Hospital casualty management	Multiple hospitals	Operational  Strategic	Infectious disease	<i>In-situ</i>  Real medical/ decontamination tools	Moulaged actors/ casualties	Real-time Time pressure

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Author [year] (ref.)	Country	Purpose	Scope: geographical	Scope: functional	Scope: organisational	Scope: administrative	Threat	Fidelity: environmental	Fidelity: physical	Fidelity: functional
Nathawad <i>et al.</i> [2013] (26)	USA	Test preparedness	Single site	Hospital casualty management	Single hospital	Operational Strategic	Infectious disease	<i>In-situ</i> Simulated incident command	Moulaged actors/casualties	Real-time Time pressure Behavioural challenges
Perry [2004] (27)	USA	Improve methods	City	Pre-hospital casualty management	Multi agency	Operational	CBRN	<i>In-situ</i> Atmospheric FX	Moulaged actors/casualties	Real-time Time pressure Behavioural challenges
Shah <i>et al.</i> [2014] (29)	USA	Test preparedness	Single site	Hospital casualty management	Single hospital	Operational	CBRN	Simulated incident command Simulated incident site	Moulaged actors/casualties	Real-time Time pressure
Siegel <i>et al.</i> [2003] (30)	USA	Test preparedness	Single site	Pre-hospital casualty management	Multi agency	Operational Strategic	CBRN	<i>In-situ</i>	Moulaged actors/casualties Real medical/decontamination tools Real transport	Real-time Time pressure
Thew [2003] (37)	USA	Test preparedness	Regional	Pre-hospital casualty management	Single agency	Operational Strategic	CBRN	<i>In-situ</i>	Moulaged actors/casualties Real medical/decontamination tools	Real-time Time pressure
Weil [2003] (36)	USA	Test preparedness	Regional	Hospital casualty management	Single hospital	Operational Strategic	CBRN	<i>In-situ</i>	Moulaged actors/casualties Real communication tools	Real-time Time pressure

FX, functional exercise; ref., reference; CBRN, chemical, biological, radiological, or nuclear.

**FX: outcomes (n=13)**

Author [year] (ref.)	Plans/protocols	Clinical skills	Decontamination	Resources	Communication
Denny <i>et al.</i> [2005] (17)	–	–	–	–	Technology use Improvements
Djalali <i>et al.</i> [2014] (48)	Adherence	Triage	–	Availability	Efficiency/quality
Edwards <i>et al.</i> [2006] (45)	–	–	Containment Casualty management	Training Equipment issues	–
Fitzgerald <i>et al.</i> [2003] (18)	–	Triage	Casualty management	Management	–
Haverkort <i>et al.</i> [2016] (49)	Identify gaps/issues	–	–	–	Technology use
Hoffman and Norton [2000] (19)	–	Triage Infection control procedure	–	Availability Management	–
Kohlhoff <i>et al.</i> [2012] (23)	Identify gaps/issues Modifications	Infection control procedure	–	Management	–
Nathawad <i>et al.</i> [2013] (26)	–	Infection control procedure	–	Management Equipment issues	–
Perry [2004] (27)	–	–	–	–	–
Shah <i>et al.</i> [2014] (29)	Adherence	–	–	Availability Management	–
Siegel <i>et al.</i> [2003] (30)	–	–	Protocols/procedures Casualty management	Availability Management	Efficiency/quality
Thew [2003] (37)	Adherence	–	–	–	–
Weil [2003] (36)	Modifications	–	–	Training Availability	Efficiency/quality

FX, functional exercise; ref., reference.



*LD: design (n=10)*

Author [year] (ref.)	Country	Purpose	Scope: geographical	Scope: functional	Scope: organisational	Scope: administrative	Threat	Fidelity: environmental	Fidelity: physical	Fidelity: functional
Arora <i>et al.</i> [2014] (38)	UK	Improve preparedness	Single site	Hospital casualty management	Single hospital	Operational	Mass casualty	<i>In-situ</i>	Moulaged actors/ casualties Real medical/ decontamination tools	Real-time Time pressure
Jasper <i>et al.</i> [2005] (20)	USA	Test	Regional	Hospital casualty management	Multiple hospitals	Operational	CBRN	<i>In-situ</i>	Moulaged actors/ casualties Real medical/ decontamination tools	Real-time Time pressure
Jung <i>et al.</i> [2016] (21)	USA	Test	Single-site	Pre-hospital casualty management Hospital casualty management	Single hospital	Operational	Mass casualty	<i>In-situ</i>	Moulaged actors/ casualties Real medical/ decontamination tools Real transport	Real-time Time pressure
Kotora <i>et al.</i> [2014] (24)	USA	Improve preparedness	Single-site	Hospital casualty management	Single hospital	Operational	Mass casualty	<i>In-situ</i>	Moulaged actors/ casualties Real medical/ decontamination tools	Real-time Time pressure
Leiba <i>et al.</i> [2006] (43)	Israel	Improve preparedness	City	Pre-hospital casualty management Hospital casualty management	Multiple agencies	Operational	CBRN	<i>In-situ</i>	Moulaged actors/ casualties Real medical/ decontamination tools	Real-time Time pressure
Mbanjumucyo <i>et al.</i> [2018] (47)	Rwanda	Improve preparedness	Regional	Pre-hospital casualty management	Multiple agencies	Operational	Mass casualty	<i>In-situ</i>	Moulaged actors/ casualties Real transport	Real-time Time pressure No notice
Peterson and Perry [1999] (35)	USA	Test	City-wide	Pre-hospital casualty management	Single agency	Operational	Mass casualty	<i>In-situ</i>	Moulaged actors/ casualties Real medical/ decontamination tools	Real-time Time pressure
Rehn <i>et al.</i> [2011] (50)	Norway	Improve preparedness	City-wide	Pre-hospital casualty management Hospital casualty management	Multiple agencies	Operational	Mass casualty	<i>In-situ</i>	Moulaged actors/ casualties Real medical/ decontamination tools	Real-time Time pressure
Vinson [2007] (33)	USA	Improve preparedness	Single-site	Hospital casualty management	Multiple agencies	Operational	CBRN	<i>In-situ</i>	Moulaged actors/ casualties Real medical/ decontamination tools	Real-time Time pressure
Wexler and Flamm [2017] (34)	USA	Improve preparedness	Single-site	Hospital casualty management	Single hospital	Operational	Mass casualty	<i>In-situ</i>	Moulaged actors/ casualties	Real-time Time pressure

LD, live drill; ref., reference; CBRN, chemical, biological, radiological, or nuclear.

**LD: outcomes (n=10)**

Author [year] (ref.)	Plans/protocols	Clinical skills	Decontamination	Resources	Communication
Arora <i>et al.</i> [2014] (38)	-	-	-	-	-
Jasper <i>et al.</i> [2005] (20)	-	-	Protocols/procedures Casualty management	Availability Management	-
Jung <i>et al.</i> [2016] (21)	Adherence	-	Protocols/procedures	Availability	Technology use Improvements
Kotora <i>et al.</i> [2014] (24)	-	-	-	Training Management	-
Leiba <i>et al.</i> [2006] (43)	-	Triage/diagnostic accuracy	-	-	-
Mbanjumucyo <i>et al.</i> [2018] (47)	Adherence	Triage	-	-	Efficiency/quality Improvements
Peterson and Perry [1999] (35)	Identify gaps/issues Adherence	-	-	-	-
Rehn <i>et al.</i> [2011] (50)	-	-	-	Availability Management	-
Vinson [2007] (33)	-	-	-	Training Availability	-
Wexler and Flamm [2017] (34)	-	Triage	-	-	Efficiency/quality

LD, live drill; ref., reference.