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Systematic literature review on lessons learnt from terrorist attacks with a focus on pre-hospital and in-hospital management

Systematische Literatur Recherche über Terrorangriffe mit dem Fokus auf präklinischer und klinischer Versorgung von Verletzten

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Abstract English

Purpose: The threat of national and international terrorism remains high. Preparation is the key requirement for the resilience of hospitals and out-of-hospital rescue forces. The scientific evidence for defining medical and tactical strategies often feeds on the analysis of real incidents and the lessons learned derived from them. This systematic review of the literature aims to identify and systematically report lessons learned from terrorist attacks since 2001.

Methods: PubMed was used as a database using predefined search strategies and eligibility criteria. All countries that are part of the Organization for Economic Cooperation and Development (OECD) were included. The time frame was set between 2001 and 2018.

Results: 68 articles were included in the review. From these, 616 lessons learned were extracted and summarized into 15 categories. The data shows that despite the difference in attacks, countries, and casualties involved, many of the lessons learned are similar. We also found that the pattern of lessons learned is repeated continuously over the time period studied.

Conclusions: The lessons from terrorist attacks since 2001 follow a certain pattern and remained constant over time. Therefore, it seems to be more accurate to talk about lessons identified rather than lessons learned. To save as many victims as possible, protect rescue forces from harm, and to prepare hospitals at the best possible level it is important to implement the lessons identified in training and preparation.

Abstract Deutsch

Zweck: Die Bedrohung durch den nationalen und internationalen Terrorismus ist nach wie vor hoch. Vorbereitung ist die zentrale Voraussetzung für die Resilienz von Krankenhäusern und außerklinischen Rettungskräften. Die wissenschaftliche Evidenz für die Definition medizinischer und taktischer Strategien speist sich oft aus der Analyse realer Vorfälle und der daraus gezogenen Lehren. Diese systematische Literaturübersicht zielt darauf ab, Lehren aus Terroranschlägen seit 2001 zu ziehen und systematisch aufzuarbeiten.

Methodik: Als Datenbank wurde PubMed verwendet. Dabei wurden bestimmte Suchstrategien und Auswahlkriterien genutzt. Alle Länder, die Teil der Organisation für wirtschaftliche Zusammenarbeit und Entwicklung (OECD) sind, wurden aufgenommen. Der Zeitrahmen wurde zwischen 2001 und 2018 festgelegt.

Ergebnisse: 68 Artikel wurden in die Literaturrecherche inkludiert. Daraus wurden 616 gewonnene Erkenntnisse extrahiert und in 15 Kategorien zusammengefasst. Die Daten zeigen, dass trotz des Unterschieds bei den Angriffen, Ländern und Opfern, viele der gewonnenen Erkenntnisse ähnlich sind. Wir fanden auch heraus, dass sich das Muster der gelernten Lektionen während des untersuchten Zeitraums immer wieder wiederholte.

Schlussfolgerungen: Die Lehren aus Terroranschlägen seit 2001 folgen einem gewissen Muster und blieben im Laufe der Zeit konstant. Um so viele Opfer wie möglich zu retten, die Rettungskräfte vor Schaden zu bewahren und Krankenhäuser auf dem bestmöglichen Niveau vorzubereiten, ist es wichtig, die identifizierten Lektionen in der Ausbildung und auch in der Einsatzvorbereitung umzusetzen.

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Introduction

The events of September 11, 2001 marked a turning point in our westernised world. It served as a wakeup call that, states, even superpowers, can be challenged and threatened in unorthodox ways by non-state actors. Since 9/11 we have witnessed the "War on Terror", which has seen the invasion of Afghanistan, Iraq and Syria and has added further instability to a highly volatile environment.[1] The ongoing civil wars in the Middle East, the resulting refugee crisis, the rise in nationalist sentiments and the increased fear of terrorist attacks within the westernised world are nowadays part of everyone's reality. With this our narrative changed. Our political as well as our social systems had to adapt to this changing reality. Suddenly, intentional mass casualty incidents with an ongoing threat to the lives of civilians as well as rescue forces were scenarios that had to be dealt with. This was a direct consequence of the terrorism narrative that took hold of Europe and the Western world. Rescue services had to adapt their standardised procedures in order to be equipped for this new challenge of "terrorist incidents". Not only were they faced with a different spectrum of injuries in prehospital care but also with new treatment concepts and priorities and most importantly the constant threat of an ongoing terrorist attack.[2] A TEMS doctor, who treated wounded during the Bataclan terror attacks in France in 2015 describes the situation as "being in a war zone without a bullet proof vest".[3] Even though this topic is very emotional, it also bears high academic interest. Lessons can be learnt from each attack and its aftermath. These lessons can help improve training of the rescue services and hence provide better preparation for and more coordinated operations during future terrorist attacks.

This study is a systematic review of the academic literature that exists around the topic of medical treatment after terrorist attacks. It sets out to extract, compile, evaluate and categorise the lessons learnt after terrorist attacks. It does this by evaluating the academic work written and reports published after various terrorist attacks.

Background

Before being able to academically evaluate the existing literature, it is mandatory to define the terms used in the research and place its content into context. The background section will hence be used to define the term terrorism, describe its evolution since 2001 and highlight the differences for rescue services and hospitals when dealing with terrorist attacks rather than "only" mass casualty incidents.

Definition of terrorism

Defining terrorism is a difficult yet important task in order to allow a clear understanding of the basis of discussion and a sufficient understanding of the phenomenon. As Erik Männik states in his article *Terrorism - Its past, present and future prospects*: "The use of violence with the aim of creating fear in a wider audience in order to prevent various parties from doing something, or, on the contrary, to coerce them into a certain behaviour, is as old as mankind. Such use of violence has served states and various regimes over a long period of time."[1] [4] Considering that the concept of terrorism has been around for centuries and has been abused by multiple different parties, it comes as no surprise that there is no single, unifying definition. State terrorism used during the French Revolution or Stalinist Russia is as much part of this spectrum as the attacks of 9/11, Guy Fawkes attempt to blow up the British Parliament or Claus von Stauffenberg's attempt to assassinate Hitler during the 20th July plot.[4] As one can already see the concept of terrorism is not inherently evil in the same way it is not inherently linked to a specific group of people. The North Atlantic Treaty Organisation (NATO) defines terrorism as:

"The unlawful use or threatened use of force or violence against individuals or property in an attempt to coerce or intimidate governments or societies to achieve political, religious or ideological objectives"[2] [5]

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[1] Erik Männik; Its past, present and future prospects p. 152
[2] C C. SecBrief.org - Definition of Terrorism. Published March 6, 2016.

whereas the European Union sees terrorism as an act to:

- "seriously intimidating a population;
- unduly compelling a government or international organisation to perform or abstain from performing any act;
- seriously destabilising or destroying the fundamental political, constitutional, economic or social structures of a country or an international organisation." [3] [4]

These definitions of terrorism show that it can be performed through various illegal means – by hijacking planes, threatening the lives of individuals or groups, cutting vital services to society – and is therefore not linked to a particular ideology or movement but is rather a method employed to achieve certain aims. In this way it does not necessarily bear an ideological or political charge and hence gives a comprehensive, widely applicable definition under which most terrorist acts can be classified.[4] The EU as well as the NATO definition of terrorism make it clear that the current understanding of terrorism is based on an unlawful act with the aim to destabilise and intimidate. This implies that the actors being intimidated are democratically elected, constitutionally backed structures and hence enforces the "good" versus "bad" idea of terrorism. As the Stauffenberg example shows, it is not quite that simple however but diving into this opens a whole new discussion on forms of government, democracies, and human rights.[4] That is why this flaw will be ignored and the main ideas behind the EU as well as the NATO definition of terrorism will be used as the basis for this systematic review and all articles analysed will have experienced terrorism in a sort of way that fits this definition.

Terrorism can furthermore be classified according to affiliations. Lone actor terrorism, internationally active terrorist groups as well as domestic terrorist groups are part of a spectrum of terrorism with different goals, intentions and often practices.

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[3] Erik Männik; Its past, present and future prospects p.154

Lone Actor Terrorism

"Lone actor terrorism is defined as terrorist acts committed by individuals who act alone and without the support of a terrorist organisation."[(4) 6] This is not a new phenomenon but has become rather popular in recent years especially after ISIL's call for independent attacks by individuals in 2014.[6] This type of terrorism has the potential to cause high casualty numbers as could be seen in the attacks in Orlando (USA) and Nice (France) 2016. Lone actor terrorism was responsible for 22% of terrorist deaths in OECD (Organisation for Economic Cooperation and Development) countries in 2015 according to the Global Terrorism Index. [6]

Domestic terrorist group

Domestic terrorist groups are mainly motivated by nationalism, anti – government sentiment, racism or separatism.[6] They often belong to independence movements, which have sworn to use unlawful means, if necessary, in order to achieve their goals. The most prominent groups within the OECD are the IRA of Northern Ireland, the ETA organisation of Spain and the PKK, which is active in Turkey.[6] All of the above are separationist movements with the unifying goal of independence. A second form of domestic terrorism is home grown terrorism. The 2005 London bombings would fall under this category, as the perpetrator of these attacks was a group of citizens, born and bred in Britain, motivated by jihadist beliefs and opposed to Britain's current foreign policy at that time.[6] Even though this is a very diverse classification due to an array of different motivations behind the formation of various domestic terrorist groups, extensive research has shown that they generally come into existence "when group grievances against the state are high, and the opportunity cost of joining a rebellion is low. " [(5) 6]

International terrorist group

Especially 2015 and 2016 has seen ISIL turn into the most prominent and well-known international terrorist organisation in the OECD due to numbers of attacks

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[4] Institute for Economics and Peace. Global Terrorism Index 2016 p.45
[5] Institute for Economics and Peace. Global Terrorism Index 2016 p.46

as well as numbers of death through attacks.[6] Over 31000 people have travelled to Iraq and Syria to join ISIL and their cause from all over the world.[6] The overwhelming motivation to join an international terrorist group seems to be more personal rather than political, with the key impetus being described as a sense of isolation within western culture.[7] The US counter terrorism centre found that the average international ISIL fighter is male, 26 years of age, has a relatively low level of Islam knowledge but a relatively high level of education. "The differing knowledge of Islam appears to have an influence on the types of roles within ISIL that people choose. Twelve per cent of recruits opted for a suicide role over a more conventional fighting role, with those who had advanced knowledge of Islam and Sharia being far less likely to choose the suicide role than those with more limited knowledge." [(6)] [6] Personal issues such as education and employment mismatch rather than political, religious or nationalistic beliefs seem to be the main driving force for joining an international terrorist group. This stands in contrast to the reasons of joining a domestic terrorist groups.

All three different subtypes of terrorist organisations have played a role when it comes to the terror attacks that have been committed in the westernised world since 2001 and are the focus of this paper. Hence all three groups will be considered.

Evolution of terrorism since 2001

2015 was the worst year for terrorism in OECD countries since 2001, recording the highest number of attacks. (Figure 1) The number of attacks in OECD countries rose for the sixth year running, reaching 731 attacks in 2015.[6] This was a 23 per cent increase from the previous high of 592 in 2004.[6] Twenty-one of the 34 countries in the OECD suffered from an attack in 2015.[6] 2015 was also the worst year for deaths from terrorism for OECD countries aside from the

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[6] Institute for Economics and Peace. Global Terrorism Index 2016 p.48

September 11 attacks in 2001. The prior peak was in 2004, when 272 people were killed.[6]

DEATHS FROM TERRORISM IN OECD COUNTRIES, 2000 TO JULY 2016

In 2015 deaths from terrorism increased by 650 per cent compared to 2014. This was the second worst year for terrorism in the OECD after 2001 with the September 11 attacks.

Source: START GTD, IEP calculations, IEP estimates
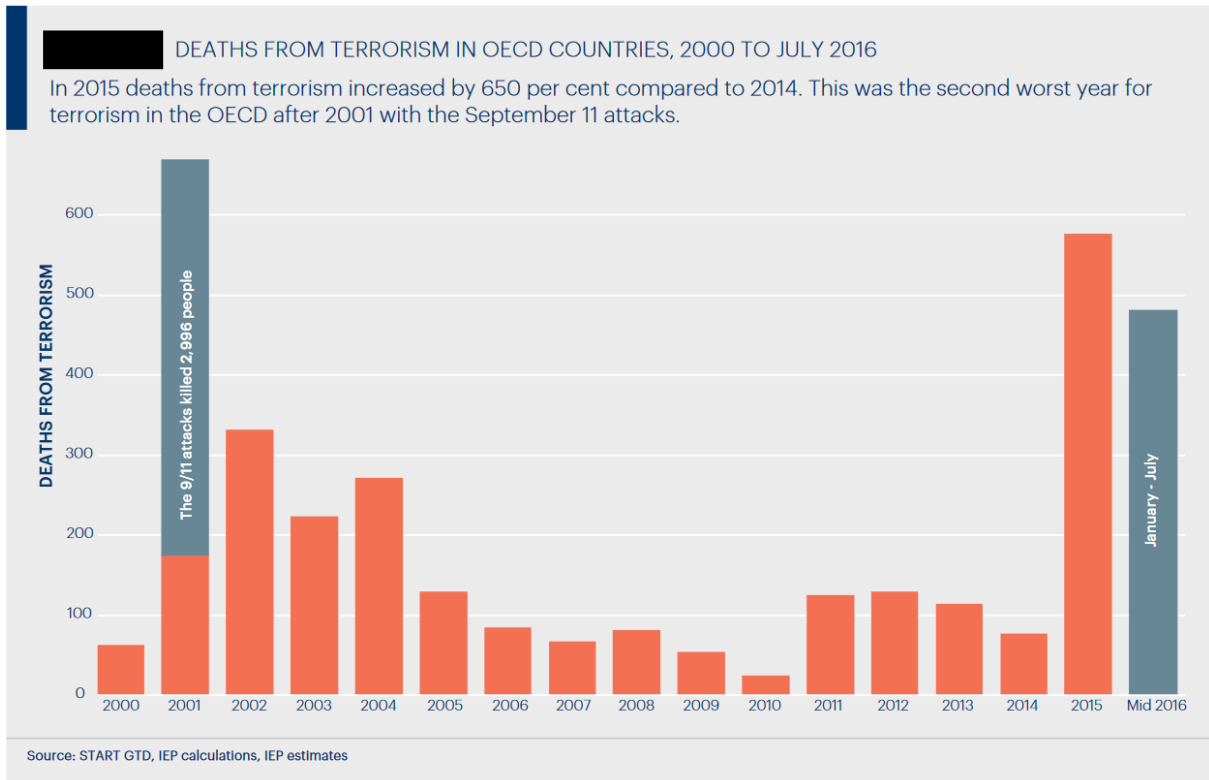
Figure 1 Deaths from terrorism in OECD countries - Institute for Economics and Peace. Global Terrorism Index 2016. http://economicsandpeace.org/wp-content/uploads/2016/11/Global-Terrorism-Index-2016.2.pdf

The number of deaths from terrorism in OECD countries had not exceeded 130 people in a single year for the last decade before 2015. Since 2004, deaths had remained relatively low, but jumped from 77 in 2014 to 577 in 2015.[6] According to the Global Terrorism Index of 2015 nine OECD countries reported the highest level of terrorism since the year 2000 and five recorded the most deaths in a single year. Since the new millennium, two periods of high fatality terrorist activity have been recorded within the OECD. The first period dates from 2001 to 2005 obviously centring around the September 11 attacks in 2001, which killed 2996 people and brought the problem of terrorism to the forefront of everybody's mind.[6] Additionally the Al – Aqsa Martyrs Brigade, Hamas and Palestinian Islamic Jihad increased activities during the years of 2002 and 2003 correlating to the Second Intifada, a period of armed conflicts between Israeli and Palestinians causing the

death of thousands. The majority of deaths in 2004 and 2005 resulted from two attacks by al-Qa'ida. Firstly the Madrid attacks in 2004 killing 191 people and accounting for 70% of all deaths by terrorism in the OECD countries that year and secondly the bombings in London in July 2005, killing 56 people.[6] The second peak of deaths through terrorism within the OECD happened between 2014 and 2016, with 2015 being the first year within a decade that more than 150 deaths due to terrorism were recorded.[6] Despite climbing numbers since 2010, deaths from terrorism had remained consistently low until the year 2015. This new rise in terrorist associated deaths coincided with the rise of ISIL and ISIL inspired attacks which swept through Europe and the OECD countries. A 67% increase in terror attacks was recorded between 2014 and 2016 with a steep increase of 600% in deaths from terrorism.[6] This major increase can be attributed to a few attacks with high numbers of fatalities. The 2015 Paris attacks resulted in the death of 130 casualties while the July 2016 Nice truck attack killed 87 and the June 2016 Orlando nightclub shooting 50.[8-10] These three attacks alone accounted for 44% of all deaths from terrorism between 2014 and 2017.[6] Both, foiled and realised terrorist attacks have been on the rise throughout OECD countries since 2014.[6] Improvements such as greater resource allocation towards counterterrorism and improvements in counterterrorism strategies have helped in preventing many attacks while on the other hand, the change to non-traditional targets and less sophisticated attacks allowed for deadlier attacks.[6] France, which has experienced one of the highest numbers of deaths from terrorism, has however also managed to foil a quarter of all attacks, which is a far higher proportion than countries with fewer deaths from terrorism such as the Czech Republic for example.[6] Even though there doesn't seem to be a linear relationship between the number of terrorist attacks a country experiences and its ability to thwart these attacks, it does look like countries with a history of domestic terrorism are more successful in foiling them.[6] The greater experience of dealing with attacks as well as the greater resource allocation towards counterterrorism are probably two of the main reasons for this relationship.

Terrorism and Medicine

The medical and surgical management of casualties of terroristic attacks has been given great attention throughout the years. Even though the SARS – CoV – 2 pandemic has taken the world at ransom, recent attacks in France, Austria, the United Kingdom, Germany and other places have shown that this particular threat is far from over and highly relevant today.[11-14] The idea to stop the killing as well as the dying, which was mentioned by Park et al. after the London Bridge and Borough Market attacks in 2017 emphasizes the needed focus on medical management and early medical as well as surgical intervention.[15] In most countries the emergency medical services are not trained to operate in the hot zone of a terror attack.[15] This means that close cooperation between police and medical services are vitally important to fill the treatment vacuum that might be present during an ongoing attack. Whilst it is important to stop the killing as soon as possible, it is also of critical importance to start treating patients as quickly as possible without exposing medical staff to undue risks. This is a difficult scenario that is not 100% unique to terror attacks as natural disasters such as fires can cause similar issues, but more often than not these risks are already fully controlled when the emergency medical services start their work. The dangers of a second hit, an uncontrolled active shooter targeting paramedics or the fear of terrorists invading hospitals disguised as victims, make it however a very prominent feature of medical treatment concepts during terrorist attacks.

Difference in medical management during terrorist attacks and other mass casualty incidents

Medical Rescue during Civil Mass Casualty Incidents

In order to explore the differences between medical management during terrorist attacks and medical management during civil mass casualty incidents, the basic concepts need to be outlined first.

Health care systems have always been involved in the management of mass casualty incidents. According to the article "Prehospital organization and management of a mass casualty incident" there are four distinct stages of a major

incident: initial response, consolidation phase, recovery phase and restoration of normality, which can vary in length according to the type of incident.[16]

A major mass casualty incident is defined as any incident that requires extraordinary resources and tend to be classified as; natural or man-made, simple or compound and compensated or uncompensated.[16]

Whilst natural major incidents are natural catastrophes like wildfires, earthquakes or tsunamis, which do not only lead to injuries and illnesses but also have the added complication of homelessness, limited supplies and the risk of infectious diseases, man-made incidents happen when large groups of people are in close proximity or crowded places.[16] The second classification distinguishes incidents where the infrastructure is not affected (simple) from incidents where infrastructure, communication channels, political structures or health care services are affected and complicate the recovery and restoration phase (compound). The final classification focuses on the capacities needed to recover the situation. In compensated major incidents the workload can be managed with the additional capacities who have been called upon whereas in an uncompensated incident even the additionally mobilized capacities are not enough to cope with the amounts of casualties presented. Most incidents encountered by health care services in the westernized world are of a manmade, simple, compensated kind which can be dealt with effectively by mobilizing additional capacities.[16]

Major incidents can be declared by any of the emergency services typically using the METHANE pneumonic which stands for major incident/ exact location/ type/ hazard/ access/ number of casualties/ emergency services needed.[17] A major incident for one type of emergency service does not necessarily constitute a major incident for another even though if in doubt it is easier to place personnel, hospitals and additional capacities on standby until further notice.

"When a major incident is declared,(…) initial priorities are to save life, relieve suffering, and prevent escalation of the incident followed by protection of the

environment, preservation of infrastructure, and property with a subsequent restoration of normality and facilitation of enquiries."[7] [16]

Even though the acute threat is often already under control during a mass casualty incident, zoning is still one of the most important decisions to be taken in the early management phase. The distinction between an unsafe zone where only fire services/the police act and a safe zone, which includes designated treatment areas for casualties and the on-site command and control points of the emergency services, is important. The tactical command post is located within the safe zone and is responsible for planning and coordinating the response of the different services, gathering information and directing resources accordingly. It is the central hub of information gathering and planning.[16] Strategic command is mostly remote to the incident site and connected through various communication channels with the tactical command hub. Its main job is to mobilise further resources if necessary, to liaise with other organization including the army, hospitals, governments or public health organizations. A further important point of infrastructure is a casualty clearing station where ambulances have easy and safe access to the incident site in order to transport casualties to hospitals according to a priority index and non-injured survivors can leave the incident zone in a safe and orderly manner.

The main aim is to deliver the "right patient to the right place at the right time" [8][16] to allow for the delivery of the right care for this patient. Good communication between the strategic and tactical command stations allows for an organized transport to different hospitals without overwhelming the end care provider and their capacities. Stationing experienced health care commanders in charge at the various junctions is vital to allow smooth evacuation. Close communication between medical services and the police/fire services ensures safe ambulance access via an access point, a safe ambulance parking and loading zone and a safe exit site. Continuous logging of casualty numbers and fair and even distribution to nearby hospitals as well as good communications with the end care

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[7] Lowes, Cosgrove; Prehospital organization and management of a mass casualty incident 2016 p.2
[8] Lowes, Cosgrove; Prehospital organization and management of a mass casualty incident 2016 p.3

providers can enhance the delivery of care. Even though mass casualty incidents are rare they can have devastating short and long – term effects on infrastructure, society and health.[16] Having solid concepts in place to be able to respond to these devastating events is vital to minimize these negative consequences.

Medical Rescue during terrorist attacks and its differences

Terror attacks are a new phenomenon on the landscape of mass casualty incidents and whilst many of the concepts of mass casualty care can be applied, there are some distinct differences that need to be considered, developed and practiced in order to be prepared for these very specific man-made events.

Wurmb at al. use a diagram which illustrates the differences in terrorist attacks that one can be faced with in their paper *Notfallmedizinische Versorgung Bei Terror- Und Amoklagen* .[18]
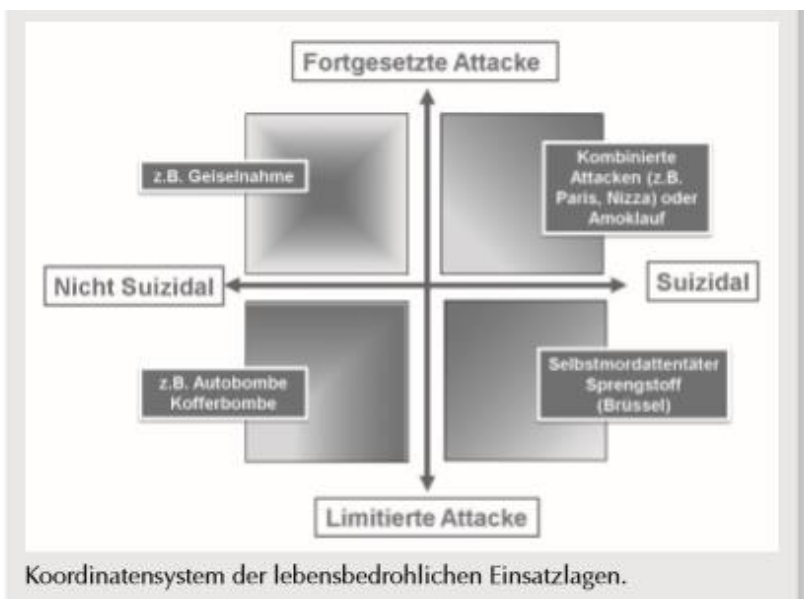
Figure 2 Difference in terror attacks - Wurmb T, Helm M, Hossfeld B. Notfallmedizinische Versorgung Bei Terror- Und Amoklagen. Refresher Course Nr. 44; 2018. (Author's and publisher's permission for display obtained)

It distinguishes between suicide and non-suicide attacks as well as limited and continuous attacks. The most dangerous of those four combinations is the continuous suicide attack as every additional minute without intervention and offender elimination means further lives threatened or lost. The overarching aim "to save as many casualties as possible whilst keeping all rescue forces safe"[18] needs to be communicated to all

participating services and should be the basis of all efforts. If this aim has been communicated and trained beforehand, the understanding between the different services can be increased, actions can be easily adapted, information overload can be avoided, and communication can be reduced to an effective minimum in real life situations.[18] The strategy to achieve the overall aim, has to adapt to the differences a life-threatening rescue mission displays in comparison to a mass casualty incident. The focus should therefore be on the continuous threat, the possibility of a second hit and the difference in weapons and resulting injury patterns. Medical strategies for most mass casualty incidents focus on the idea of an isolated concluded event without any ongoing threats. Hence a structured, well organised casualty search, categorisation of patients and stabilising treatment before transport to hospital can be organised in an orderly fashion. During a life-threatening mass casualty incident such as a terrorist attack the threat of further attacks targeting civilians but also rescue services is constantly present as long as the police has not eliminated the perpetrator.[18] Because of this, the length of stay of casualties as well as medical teams at the site of attack should be as minimal as possible and direct transport to hospital should be prioritised. This approach also saves lives, as many of the injury patterns during terrorist attacks require urgent operative intervention to reduce mortality. That's why the strategy of "Stop the killing", "Stop the dying" and "Clear up the scene immediately" is the most suited for medical rescue missions during terrorist attacks.[18]

The possibility of a second hit – possibly also directed against the rescue teams – always needs to be considered. In order to facilitate the strategy of "clearing up the scene immediately" the site of operation needs to be divided into different sectors in which different rescue services can perform their duties in the safest possible manner. This division into a safe, semi-safe and unsafe sector is the responsibility of the police and differs from a mass casualty accident by introducing the semi - safe sector mainly due to the volatile character of the situation.[18] The unsafe sector is only entered by police forces and actions focus on threat/ perpetrator elimination and evacuating or directing casualties towards the semi – safe sector where police as well as medical rescue forces are able to

perform a primary triage, stabilise vital parameters and arrange transport according to priority. The safe sector should be used to establish a car park for rescue vehicles and a casualty clearing station where smooth arrival and departure of ambulances are possible. In comparison to mass casualty accidents no treatment areas should primarily be established at the incident site.[18] This has two main reasons. Firstly, most injuries sustained during a terrorist attack need urgent definitive surgical care, which cannot be provided at the incident site. Secondly the safety of the casualties as well as the rescue teams is greatly improved by spending as little time as possible at the incident site. A further difference between mass casualty accidents and terrorist attacks is the threat of perpetrators posing as patients. All casualties need to therefore be screened and possibly even undressed at some point before reaching the hospital to avoid the chances of a successful second hit within hospital by terrorist forces. [18]

The triage during a terrorist attack should be broken down to a bare minimum in accordance with Tactical Combat Casualty Care Concepts.[19] The algorithm used during the Bataclan attack was based on two simple questions [18]:

1. Is the casualty dead or alive?
2. Can he/she walk or not?

If alive and able to walk, casualties were directed towards the semi-safe sector, if unable to walk three more questions were asked:

1. Is there critical bleeding?
2. Are vital functions endangered?
3. Are there simple life saving measures that can be performed quickly (tension pneumothorax relief)

Abbildung 3

Frage 1: Tod?

Nein | Ja

Frage 2: Kann Laufen? | Kann nicht laufen? | Keine Maßnahme

Konsequenz:
Kann laufen: wird in Richtung gesicherter Bereich geleitet.
Kann nicht laufen:
1. Sind Blutungen zu stoppen?
2. Sind Vitalfunktionenen bedroht?
3. Sind einfache lebensrettende Sforotmaßnahmen indiziert?

Sichtung unter Bedrohung im unsicheren Bereich.
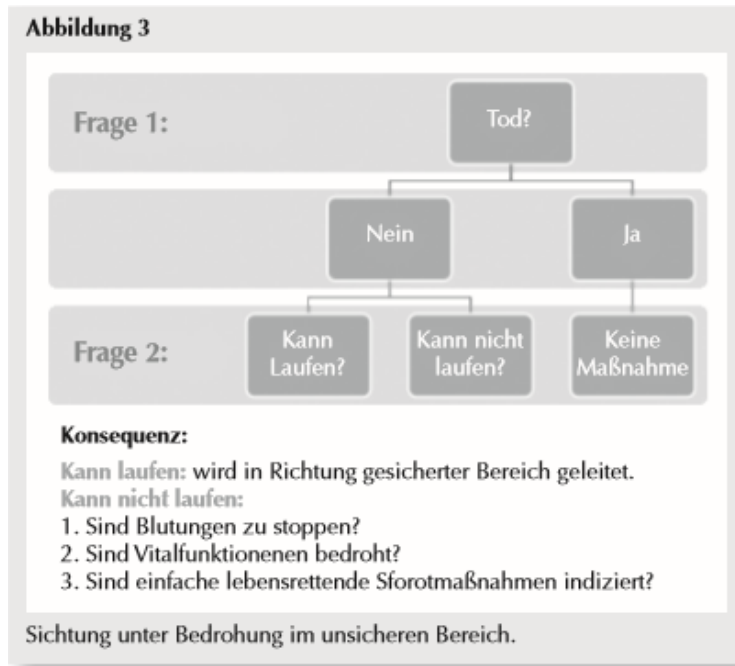
Figure 3 Triage questions - Wurmb T, Helm M, Hossfeld B. Notfallmedizinische Versorgung Bei Terror- Und Amoklagen. *Refresher Course Nr. 44; 2018.* (Author's and publisher's permission for display obtained)

This algorithm is possible in France as specially trained medical forces are operational in the unsafe sector. In most other European countries however, no medical rescue teams are operational within the unsafe sector and therefore police needs to evacuate casualties.[18] The first half of the algorithm however can easily be performed by police and with adequate training in tourniquet use, critical bleeding could also be addressed by police forces before casualties are delivered for primary triage to the semi-safe sector, where experienced doctors should be on hand to perform the triage. Primary triage is based on a colour-coordinated scheme, which translates into a severity of injury scale: red – immediate treatment required, yellow – urgent treatment required, green – delayed treatment acceptable. The triage process is basic with very limited life – saving interventions based on the C - ABC approach including tourniquet use to stop catastrophic bleeding and basic airway adjuncts to provide patent airways.[18] The purpose of primary triage is to get an overview of the casualty numbers and the array of injury whilst identifying the severely injured and relocate the uninjured or minorly injured to a place of safety. This is done with the help of colour coordinated cards to provide visual clues for further assessment and treatment.[18]

As primary triage is performed in a matter of seconds, continuous re – evaluation of a patient's status has to be ensured as a change in injury severity can happen easily and quickly. At the treatment area a swift transport to hospital is arranged for patients according to the severity of their injuries. The shift towards tactical care rather than patient centred care is even more present during terrorist attacks than it is during mass casualty accidents.

Overall one can say that the basic concept of medical rescue missions during terrorist attacks is similar to rescue missions during mass casualty incidents: Saving as many casualties as possible whilst keeping the rescue teams safe.[18] The strategy to achieve this end goal however, differs dramatically from normal mass casualty incidents as it has to firstly include "Stop the killing" before focusing on secondly "Stop the dying" and thirdly "Clearing up the scene immediately".[18] As the threat might still be ongoing and often mobile when casualty treatment starts, correct zoning and scene safety become even more important. Clear, concise and well-structured communication as well as cooperation between the different rescue forces (police, fire brigade, emergency medical services and hospitals) is more important than ever in order to avoid additional casualties. The organization of the incident scene into a safe, semi-safe and unsafe area has highest priority as it dictates access and treatment options to the medical services. The inclusion of a semi safe zone has its eligibility here, as it is often impossible to draw a clear-cut line between a safe and an unsafe zone as long as the terrorist is not arrested or eliminated. The fast transport of patients to places where definite care can be provided is vitally important due to the volatile und unsafe character of the situation and the pattern of injuries patients will display after a terrorist attack.[18] That's also one of the reasons why hospitals need to be incorporated into planning with a specific focus on operating capacity rather than only admission capacity.

Medical treatment concepts during mass casualty incidents and terrorist attacks have clear and distinct differences. If one would like to pinpoint the difference between the rescue mission during a conventional mass casualty incident and a terrorist attack it centres around the ongoing life-threatening character of a terrorist attack which needs to be understood and managed accordingly. The

situation itself and the volatile environment rather than the state of the various casualties dictate the treatment that can be provided at any given moment in time. Furthermore, communication needs to be even more highlighted, treatment needs to be moved even further from the scene and the life-threatening character of the situation for the rescue teams should never be underestimated. This is why, it is so vitally important to have altered and adjusted concepts in place and trained in order to be able to cope with these unique situations that unfortunately have become part of the incident scene.

Research Question

This research compiles a systematic literature review based on the lessons learnt from terrorist attacks with a focus on medical and surgical management within the pre – hospital as well as the hospital setting. This is achieved by reviewing the published academic literature and extracting the mentioned lessons learnt from between 2001 and 2018.

Deficits in systematic evaluation of medical management during terrorist attacks

Many of the above mentioned theoretical concepts have already been discussed, evaluated and published. The scientific evidence for medical and tactical strategies however, has to be based on the analysis of real-life incidents and lessons learnt as it is impossible to conduct prospective, high-quality scientific studies (e.g. randomized controlled trials). The published studies on this topic have either used a systematic or a narrative approach to define their lessons learnt. Within the systematic evaluations, different approaches for the definition of lessons learnt have been adopted. The range includes reports, structured consensus procedures for the definition of quality indicators and the development of an international database for the structured input and standardized evaluation of major incidents.[20,21] The Paris terror attacks in 2015 for example, have been analysed in great detail through many high ranking publication.[22,23] The

publication by the French Health Ministry and one by Carli at al., describing the "Parisian night of terror", have clearly describe the "lessons learnt" from these attacks.[24,25]   All these academic publications have given great insight into the issues encountered during the medical and surgical management of patients after terrorist attacks, but have not attempted an overarching review of the topic itself or tried to compare their findings to others.

Some efforts have been made in recent years to define quality indicators for rescue operations in major incidents. Two of these papers took an approach that covers any kind of disaster, while one group focused specifically on terrorist attacks.[26 27 28] A systematic approach to the recording of rescue operations during catastrophes was designed by Fattah et al.. The authors deployed a model for systematic descriptions of rescue operations during major emergencies.[21] This database allows the input of any kind of disaster medical missions and is not specific for terrorist attacks. Another standardized template, which aims to report all sort of major mass casualty incidents in a standardised way is DISAST-CIR. It is widely used in Israel and was published by Leiba at al.[29] Even though these concepts have helped bring the academic reporting of mass casualty incidents and their particular difficulties forward, none of them have specifically dealt with terrorist incidents.

However different the method, all experts agree about the importance of the scientific and systematic evaluation of the most recent terror attacks.[30] This is where this systematic review of the academic literature on medical and surgical management of patients after terrorist attacks comes into play. It looks at the real life data, extracts viable lessons learnt and organises them into overarching clusters. In a further step the paper tries to identify if an improvement in treatment and development of theoretical concepts based on lessons learnt has taken place over the time period covered by the research.

To the best of our knowledge, there is no systematic literature review to date that focuses exclusively on lessons learnt from medical treatment after terrorist attacks. The most similar attempt so far was a systematic review by Turner at al.

in 2016 which focused on mass shootings but did not cover the spectrum of terrorism.[31] With the aim of achieving the best possible level of evidence, and to close this gap in knowledge, we conducted a systematic literature review of the literature focusing on lessons learnt from the medical and surgical management after terrorist incidents.

Importance of Research Question

The topic of terrorism is vast and complex. Even when singling out the medical management and treatment of casualties, it is still an extensive field of research. It is however, more than ever, an important topic with acute topicality. Terror attacks have been part of our reality and the treatment of casualties is one of the top priorities when dealing with them. This is why a sound academic basis for improvement and the development of new concepts are needed.

A further focus lies on the rescue services themselves. Keeping them safe whilst performing their duty has absolute priority. Evaluating what worked well and what did not during past operations may help improve training, equipment and support and is probably the most valid reason why this research has great importance.

Focusing on a more academic perspective, having categorised lessons learnt from multiple international terror attacks can provide a basis from which national and even international standards can be derived and developed.

Methods

Country selection – the OECD

Terrorism is a worldwide phenomenon that has been around for centuries. Trying to evaluate all data of all terrorist attacks that happened since 2001 lies far beyond the scope of this study. The research has therefore concentrated on countries within the westernised world, which have not been suffering from an open conflict or civil war but have experienced an increase in terrorist attacks since 2001. Hence the focus lay on the countries which are part of the

Organisation for Economic Cooperation and Development (OECD), namely Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, the Netherland, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, The United Kingdom and the United States. Countries with inner state conflicts were purposefully excluded because as the Institute of Economics and Peace has discovered:

"When examining the drivers of terrorism the presence of armed conflict, political violence by governments, political exclusion and group grievances remain critical factors. The analysis finds that 99 per cent of all deaths over the last 17 years has been in countries that are either in conflict or have high levels of political terror".[9] [32]

In accordance with this, the ten most terrorism affected countries in 2017 were Iraq, Afghanistan, Nigeria, Syria, Pakistan, Yemen, Somalia, India, Turkey and Libya.[32] While the incidence of terrorist attacks in these countries are high, the academic evaluation of these attacks are however lacking, another reason for the exclusion of countries which, in the first instance, look like prime candidates for inclusion simply due to numbers. Furthermore, it is difficult to draw a clear distinction between civil war and terrorism, which is another reason for exclusion of these countries. The final rationale for exclusion is the lack of existing infrastructures and functioning healthcare systems in many of these countries due to their ongoing war-like states. Both these factors are however of integral importance in this research.

This research focuses therefore mainly on westernised democracies, for which a terrorist attack, is still a reasonably rare occasion and whose infrastructure and rescue services needed to adapt in recent times in order to accommodate this phenomenon. Hence, the countries of the OECD are the perfect country selection as basis of this research.

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[9] Institute for Economics and Peace. Global Terrorism Index 2017 p3

Time frame

The attack on the World Trade Centre in New York, the Pentagon in Arlington, and the crash of a hijacked airliner in 2001 is considered the event that brought international terrorism onto the world stage. The attacks have been documented and analysed in great detail. For this reason, this terrorist attack was chosen as the starting point for this investigation. The investigation ends with the terrorist attacks in London and Manchester in 2017, as the attacks after that had not been sufficiently scientifically evaluated and published at the start of the systematic review. All articles up to June 2018, which was the starting point of the research, were included. All papers within this 17-year timeframe which have been published on medical and surgical treatment after terrorist attacks, have included lessons learnt and have passed the selection process have been included. Older or more recent articles have been eliminated.

Language

The decision was taken to only include articles written in English. Even though the researcher also speaks fluent German, it was decided that, in order to allow for standardised search terms and evaluation, only English articles should be included.

Database + Search History

Pubmed was used as the data base for this research. A simple search for the term terrorism resulted in 15345 relevant articles at the time of research in July 2018. On the basis of this we decided to concentrate on Pubmed only to allow for a thorough and in depth search and evaluation of the relevant articles. We constructed a data base search around three key indicators. The first indicator concentrated on terrorism the second on medical management and the third on review/evaluation. (Figure 4)

The Pubmed Search included the terms:

Terror OR Terror Attack OR Terrorism OR Mass Casulty Incident OR Mass Shooting OR Suicide Attack OR Suicide Bomb OR Rampage OR Amok	**AND**	Prehospital Care OR Emergency Medical Service OR Emergency Service OR Emergenc Care OR Rescue Mission OR Triage OR Disaster Management OR First Response	**AND**	Lessons Learnt OR Quality Indicator OR Evaluation OR Analysis OR Review OR Report OR Deficit OR Problem

Figure 4 – Search terms systematic review

and was formulated as an advanced search in Pubmed in the following way:

Search: ((Terror* OR Terror* Attack* OR Terrorism* OR Mass Casult* Incident* OR Mass Shooting* OR Suicide Attack* OR Suicide Bomb* OR Rampage* OR Amok*) AND (Prehospital* Care* OR Emergenc* Medical* Service* OR Emergenc* Service* OR Emergenc* Care* OR Rescue Mission* OR Triage* OR Disaster* Management* OR First* Respon*)) AND (Lesson* Learn* OR Quality Indicator* OR Evaluation* OR Analysis* OR Review* OR Report* OR Deficit* OR Problem*)

The results of this search formed the basis of the data research. The included articles were then evaluated for their content and relevance by their abstract and all articles with the right topic relevance, the right time frame and the right country selection were included in the research.

Exclusion Criteria

The exclusion criteria were defined beforehand with the knowledge that some might have to be adjusted on the basis of the selection process and the article variety. The exclusion criteria were named as:

- Articles including mass casualty incidents without a terroristic background
- Articles published after June 2018

- Articles describing terrorist attacks that happened before 2001 and after 2018
- Personal Reports without any clear defined lessons learnt
- Articles dealing with CBRN terrorism

Study Evaluation

In order to evaluate the quality of the included studies, the studies were evaluated on the basis of their title, objectives, eligibility criteria, information sources, risk of bias, synthesis of results, limitation of evidence, and interpretation. This evaluation was based on a modified version of the PRISMA evaluation of abstracts in order to fit the selected set of data but at the same time be evaluated using an acknowledged reporting system. All papers were then rated as either high quality (HQ), acceptable quality (AQ) or low quality (LQ) paper.[33] [34]

Cluster Development

In order to extract the lessons learnt in an organised fashion and obtain a systematic overview it was imperative to divide them into clusters due to the vast amount of information. Initially, already existing systems were scanned for compatibility as a basis for developing the clusters. The reporting system of Fattah et al. defines 6 categories - pre-incident data, Emergency Medical Service (EMS) background, incident characteristics, EMS response, patient characteristics and key lessons.[21] These clusters were far too broad and were not sufficient to represent the many lessons learnt from the data analysis. A working group from Würzburg had recently developed 13 clusters of quality indicators to analyse major incidents.[20] 10 of these clusters could loosely be applied to give a predefined grid pattern. However, both systems focused on clusters that serve to describe the overall setting of an operation and were therefore not directly suitable for clustering lessons learnt. Having a rough pre-established cluster system based on Wurmb at al. in mind, all 68 articles were read. Whenever a lesson learnt fit into a cluster category, it was noted down. If lessons learnt were identified that did not fit a pre-established category another cluster was developed. This process resulted in the use of 15 clusters. In a

second step all articles were then once again evaluated against the final list of 15 clusters and a grid pattern that plotted the number of articles covering each category was produced. In that way a ranking of the different clusters in order of frequency and hence importance could be established. The final 15 clusters were:

- Preparedness/Planning/Training
- Tactics/Organisation/Logistics
- Medical Treatment and Injuries
- Equipment and Supplies
- Staffing
- Command
- Communication
- Zoning and Safety Scene
- Triage
- Patient flow and distribution
- Team Spirit
- Role Understanding
- Cooperation and Multidisciplinary Approach
- Psychiatric Support
- Record Keeping

Formulation of Lessons Learnt

With the help of the developed grid pattern of clusters all articles were re-evaluated and all lessons learnt extracted and grouped into the various clusters. If multiple articles mentioned the same lesson, the lesson learnt was primarily noted down once and the different articles referencing this particular lesson were recorded as attachment. In a second process all lessons learnt were then reviewed a second time to avoid any accidental overlap and then finally numbered within each cluster.

Results

Exclusion Criteria

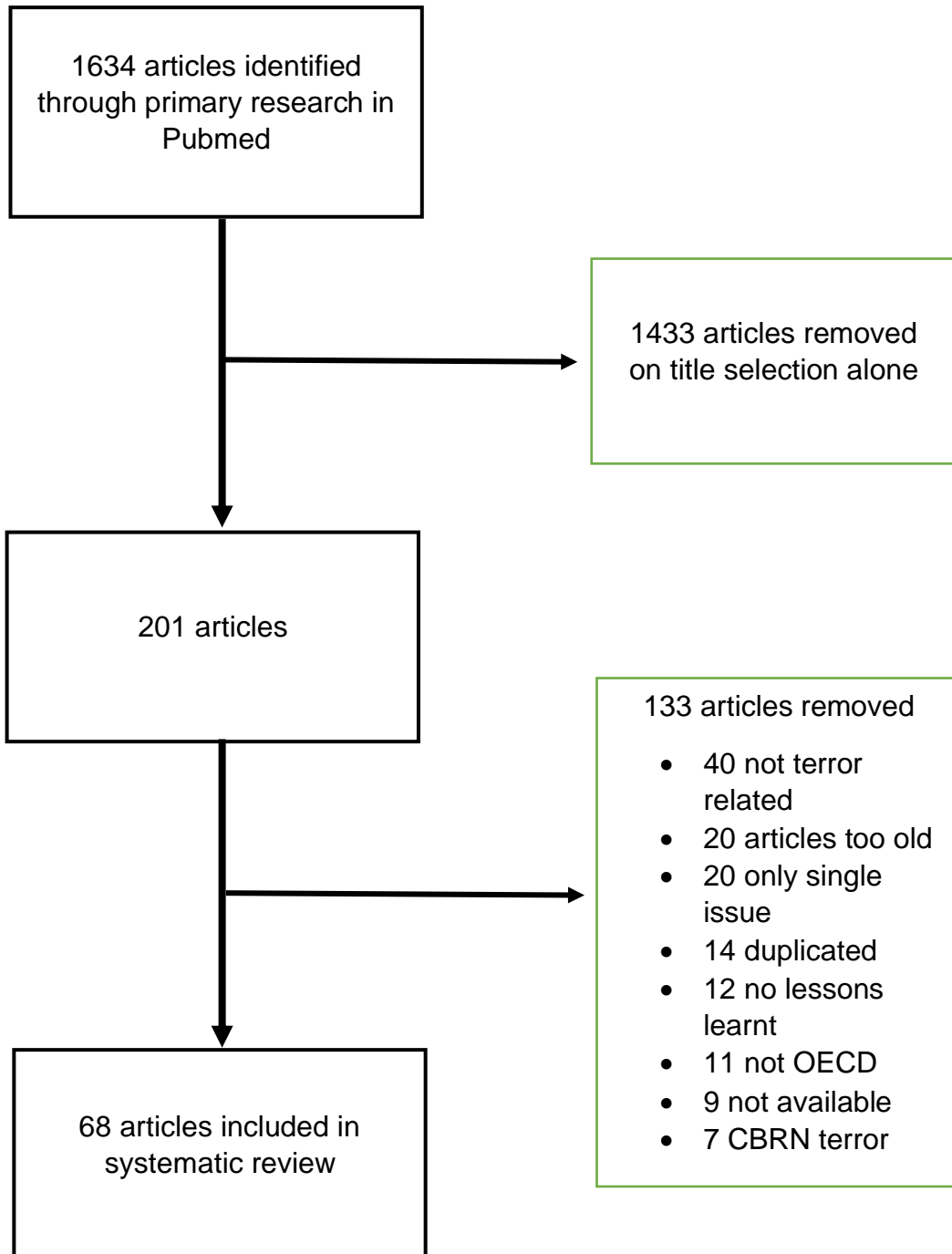|	
1634 articles identified through primary research in Pubmed	
	1433 articles removed on title selection alone
201 articles	
	133 articles removed • 40 not terror related • 20 articles too old • 20 only single issue • 14 duplicated • 12 no lessons learnt • 11 not OECD • 9 not available • 7 CBRN terror
68 articles included in systematic review	

Figure 5 – Exclusion Criteria

The structured and extensive Pubmed search with the previously described search terms yielded 1634 articles. The titles of these articles were screened and the ones missing the research question were excluded. In this way, the number of relevant articles was reduced to 201. The abstracts of these articles were evaluated for content, timeframe, country selection and type of work and finally 68 articles were included in the research. The biggest exclusion factors was focus on mass casualty incidents without a terroristic background. This was expected as we wanted to expand the search with the inclusion of the terms mass casualty incidents to not miss any important articles. Additionally, two big exclusion factors were time frame and articles which dealt with a narrow point of view and only dealt with specific types of injuries such as burns or psychiatry. This was the only exclusion criteria that had not been previously defined in the methods section. 14 articles were duplicated, 12 had no defined lessons learnt and 11 described incidents outside the OECD. A few articles were no longer available and some articles were excluded as they dealt exclusively with CBRN warfare. (Figure 5)

Prisma Evaluation of Articles

In order to evaluate the quality of the included studies, a modified version of the PRISMA evaluation of abstracts was used and all articles were rated as either high quality (HQ), acceptable quality (AQ) or low quality (LQ) paper.[33,34] Out of the 68 papers 29 were of high quality, 39 were of average quality and none were of low quality. (Table 1)

	Author	Year	Location	Study Type	Quality
1	Roccaforte et al. [35]	2001	USA 9/11	Retrospective	AQ
2	Martinez et al.[36]	2001	USA 9/11	Eye Witness	AQ
3	Cook et al. [37]	2001	USA 9/11	Eye Wittness	AQ
4	Tamber et al.[38]	2001	USA 9/11	Expert Opinion	AQ
5	Simon et al.[39]	2001	USA 9/11	Review/Report	AQ
6	Mattox et al. [40]	2001	USA 9/11	Review/Report	AQ
7	Shapira et al. [41]	2002	Israel	General Review	HQ
8	Frykberg et al. [42]	2002	Multiple	Review/Report	HQ
9	Garcia-Castrillo et al.[43]	2003	Madrid, Spain	Review/Report	AQ

10	Shamir et al.[44]	2004	Israel	Review/Report	HQ
11	Einav et al.[45]	2004	Israel	Guidelines	HQ
12	Almogy et al.[46]	2004	Israel	Review/Report	AQ
13	Rodoplu et al.[47]	2004	Istanbul, Turkey	Retrospective Descriptive Study	AQ
14	Kluger et al.[48]	2004	Israel	Review/Report	AQ
15	Gutierrez de Ceballos et al.[49]	2005	Madrid, Spain	Retrospective Study	AQ
16	Kirschbaum et al.[50]	2005	USA 9/11	Lessons Learnt	HQ
17	Aschkenazy-Steuer et al.[51]	2005	Israel	Retrospective Study	HQ
18	Lockey et al.[52]	2005	London, UK	Retrospective Study	HQ
19	Hughes et al.[53]	2006	London, UK	Review/Report	AQ
20	Shapira et al.[54]	2006	Israel	Review/Report	AQ
21	Aylwin et al.[55]	2006	London, UK	Review/Report	HQ
22	Mohammed et al.[56]	2006	London, UK	Review/Report	AQ
23	Bland et al.[57]	2006	London, UK	Personal Review	AQ
24	Leiba et al. [58]	2006	Israel	Review/Report	HQ
25	Singer et al.[59]	2007	Israel	Review/Report	HQ
26	Schwartz et al.[60]	2007	Israel	Review/Report	AQ
27	Gomez et al.[61]	2007	Madrid, Spain	Review/Report	AQ
28	Bloch et al.[62]	2007	Israel	Review/Report	AQ
29	Bloch et al.[63]	2007	Israel	Review/Report	AQ
30	Barnes et al.[64]	2007	London, UK	Government Evaluation	HQ
31	Carresi et al.[65]	2008	Madrid, Spain	Review/Report	HQ
32	Raiter et al..[66]	2008	Israel	Review/Report	HQ
33	Shirley et al..[67]	2008	London, UK	Review/Report	HQ
34	Almgody et al.[68]	2008	Multiple	Review/Report	AQ
35	Turegano-Fuentes et al.[69]	2008	Madrid, Spain	Review/Report	AQ
36	Pinkert et al.[70]	2008	Israel	Review/Report	HQ
37	Pryor et al.[71]	2009	USA 9/11	Review/Report	HQ
38	Lockey et al.[72]	2012	Utoya, Norway	Review/Report	AQ
39	Sollid et al.[73]	2012	Utoya, Norway	Review/Report	AQ
40	Gaarder et al.[74]	2012	Utoya, Norway	Review/Report	AQ
41	NN et al.[75]	2013	Boston, U.S.	Review/Report	AQ
42	Jacobs et al.[76]	2013	Israel	General Review	AQ
43	Gates et al.[77]	2014	Boston, U.S.	Review/Report	AQ

44	Wang et al. [78]	2014	Multiple	General Review	HQ
45	Ashkenazi et al.[79]	2014	Israel	Overall Review	AQ
46	Thompson et al. [80]	2014	Multiple	Retrospective	AQ
47	Rimstad et al.[81]	2015	Oslo, Norway	Retrospective	AQ
48	Goralnick et al.[82]	2015	Boston, U.S.	Retrospective	AQ
49	Hirsch et al.[22]	2015	Paris, France	Personal Review	HQ
50	Lee et al.[83]	2016	San Bernadino, U.S.	Personal Review	HQ
51	Pedersen et al.[84]	2016	Utoya, Norway	Review/Report	AQ
52	Raid et al. [85]	2016	Paris, France	Personal Review	AQ
53	Philippe et al.[24]	2016	Paris, France	Government Review	HQ
54	Traumabase et al.[86]	2016	Paris, France	Personal Review	HQ
55	Gregory et al.[87]	2016	Paris, France	Review/Report	AQ
56	Ghanchi et al.[88]	2016	Paris, France	Review/Report	AQ
57	Khorram-Manesh et al. [89]	2016	Multiple	Review/Report	HQ
58	Goralnick et al.[30]	2017	Paris/Boston	Expert Opinion	AQ
59	Lesaffre et al.[90]	2017	Paris, France	Review/Report	AQ
60	Wurmb et al. [28]	2018	Würzburg, Germany	Lessons Learnt	HQ
61	Brandrud et al.[91]	2017	Utoya, Norway	Review/Report	HQ
62	Carli et al.[25]	2017	Paris/ Nice, France	Review/Report	HQ
63	Borel et al.[92]	2017	Paris, France	Review/Report	AQ
64	Bobko et al.[93]	2018	San Bernadino, U.S.	Review/Report	AQ
65	Chauhan et al.[94]	2018	Multiple	Review/Report	HQ
66	Hunt et al.[95]	2018	London/ Manchester, UK	Review/Report	HQ
67	Hunt et al.[96]	2018	London/ Manchester, UK	Review/Report	HQ
68	Hunt et al.[97]	2018	London/ Manchester, UK	Review/Report	HQ

Table 1 – modified Prisma table

Terror Attacks

The data was firstly divided into the different terror attacks, which were covered by the articles. (Table 2) It was quite evident that a few high-profile attacks had been more extensively covered and systematically evaluated than others. (Figure 6) Whilst the terror attacks in London, Paris and Utoya had received much and also in-depth attention by various authors, others such as the San Bernadino attack or the Boston Marathon attack had only been described in one to two

articles. These articles nonetheless provided much in-depth information and evaluation of the entire process. Israel with its extensive history of terror attacks has provided a unique angle by mainly providing overall lessons learnt of multiple attacks throughout the years. A few articles took different attacks in different countries and tried to compare and evaluate them despite the differences in type of attack, in social and political structures and in the organisation of the rescue services. In this they have tried a similar approach to the research question of this paper and added much value to the content and depth of this research.

Place of Attack	Number of research articles covering attack
Würzburg, Germany	1
Istanbul, Turkey	1
Oslo, Norway	1
San Bernadino, U.S.	2
Boston, U.S.	3
Madrid, Spain	5
Utoya, Norway	5
Multiple Places	7
9/11	8
London, UK	10
Paris, France	10
Israel	15

Table 2 – places of attack
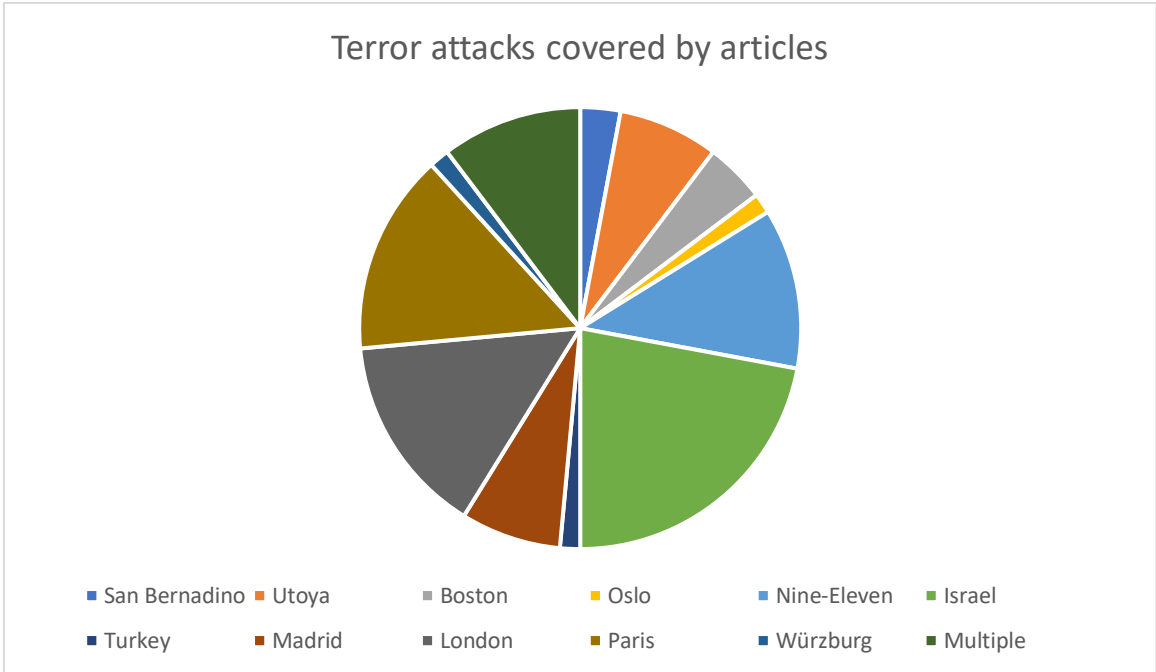
Figure 6 – terror attacks covered by articles

Type of Article

44 out of 68 articles were general reviews/reports of the information gathered during and especially after specific terror attacks. (Table 3) Other reports had already focused on comparing different terror attacks within the same country at different times in order to find similarities and some had already compared different attacks in different countries. Many of these reviews then took a second step and formulated lessons learnt. A few articles directly formulated lessons learnt without previously diving into the information gathered and a few articles were a summary of expert opinions on the post attack handling of the situation with focus on medical and surgical management. The second largest number of articles were retrospective studies which focused on one particular terror attack and gathered information from various sources post attack to provide an in-depth account of what happened, provide numbers of casualties and victims and to discuss the weaknesses and strength of the management and outcome. Especially the UK and France went even further and appointed a committee with the task to provide a thorough work up of the events and the emergency response. From that, official government papers were published, providing a thorough account of the events and clear guidelines and improvement

suggestions. There was a clear drop in numbers between the articles that were written as a report and all other reporting styles (Figure 7). A few articles were personal accounts of the events written by people who were present during the attack either as first responder or as part of the rescue force. Whilst many of the personal accounts had to be eliminated after the abstract screening for being only an emotional description of the situation, these few eyewitness reports were included as they offered very clear descriptions of the situation and the problems that the rescue services faced and formulated distinct lessons learnt and improvement possibilities.
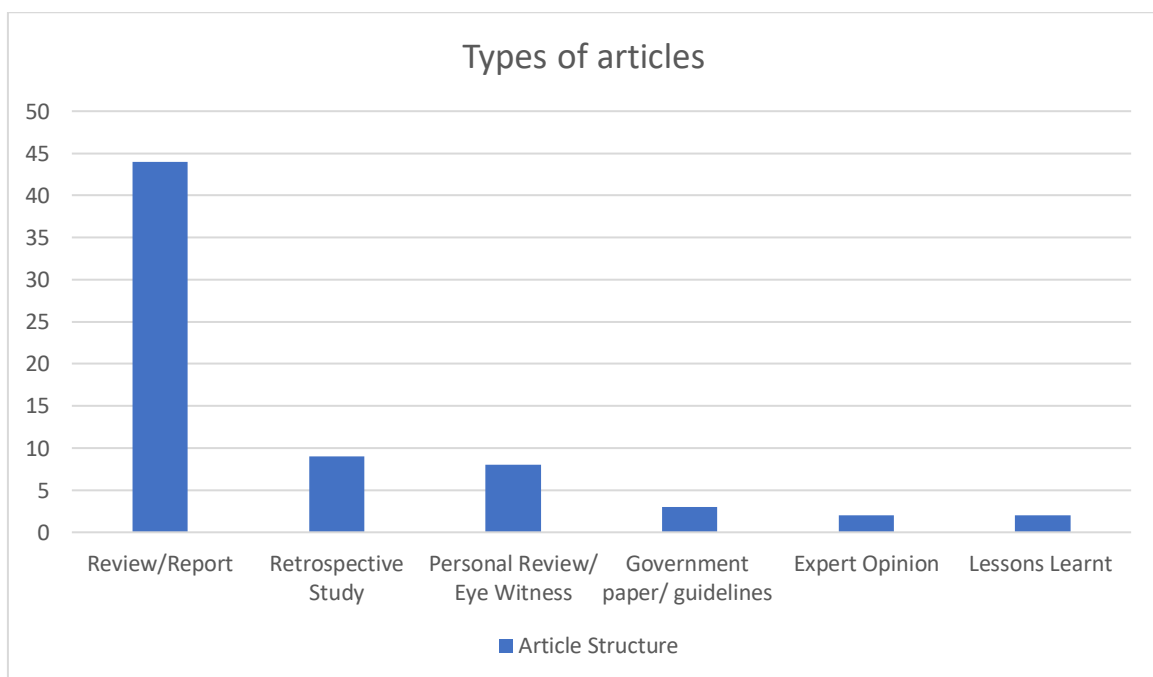
Figure 7 – type of articles

Type of Article	Numbers
Review	44
Retrospective Study	9
Personal Review/ Eye Witness Report	8
Government paper/ Guidelines	3
Expert Opinion	2
Lessons Learnt	2

Table 3 – type of articles

Pre Hospital vs Hospital Care

There was a very even distribution between articles that focused on the hospital management of victims of terror attacks, and articles that concentrated on prehospital care. Whilst 24 articles dealt with hospital treatment and the issues the hospitals faced when dealing with the mass casualty influx after a terror attack, 20 articles dealt with the direct after mass of the terror attack and the primary management of casualties on site of the attack and the difficulties the rescue services experienced. (Figure 8) 23 articles evaluated both the prehospital as well as the hospital setting and looked at the entire post attack timeframe and its multitude of potential issues. A great review of the London/Manchester bombings in 2005 divided their lessons learnt into prehospital, hospital and recovery care. As the article about the recovery period included multiple lessons learnt about communication, preparation, and supply organisation in order to be better equipped for a similar event, this article was included and was represented as the one article covering the recovery period.
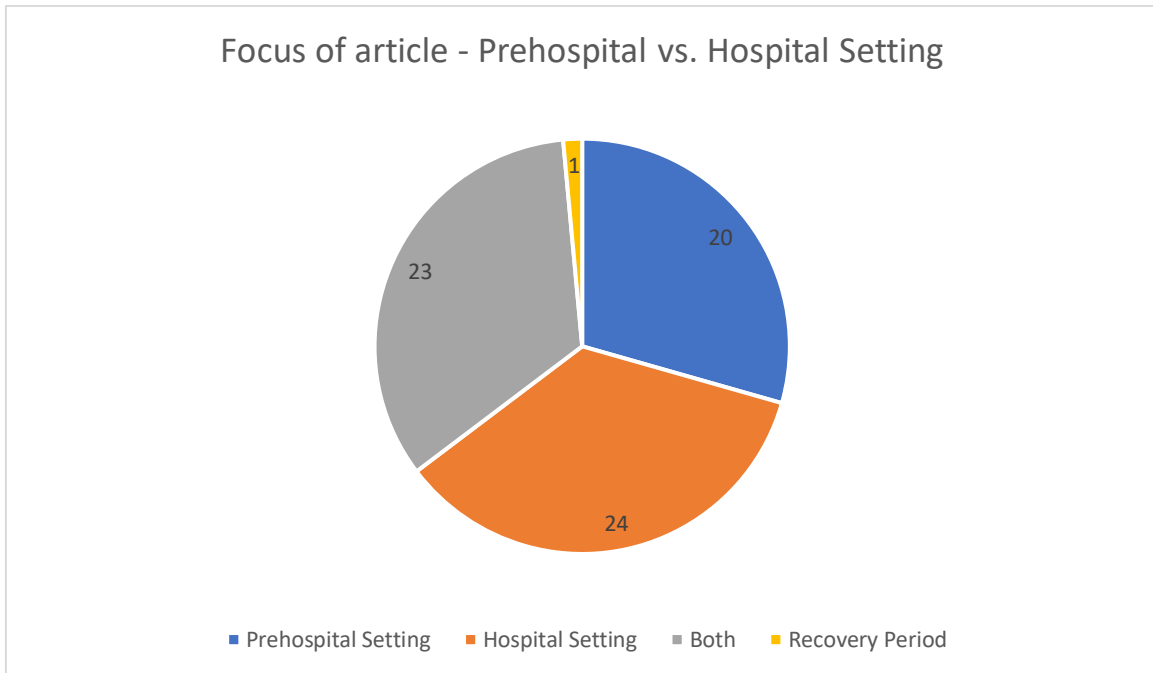
Figure 8 – focus of article – prehospital vs hospital setting

Cluster Formation

All articles were evaluated against the final list of 15 overarching clusters and a grid pattern that plotted the number of articles covering each category was produced. In that way a ranking of the different clusters in order of frequency and hence importance could be established. The final 15 clusters were:

- Preparedness/Planning/Training
- Tactics/Organisation/Logistics
- Medical Treatment and Injuries
- Equipment and Supplies
- Staffing
- Command
- Communication
- Zoning and Safety Scene
- Triage
- Patient flow and distribution
- Team Spirit

- Role Understanding
- Cooperation and Multidisciplinary Approach
- Psychiatric Support
- Record Keeping

The developed grid pattern allowed for a direct visualisation of which article mentioned which cluster. Because the articles were sorted according to date of release, it also showed if the importance of clusters had shifted over time. (Table 4)

Study	Year of Publication	Cluster 1-15 1 Tactics/Organization/Logistics 2 Communication 3 Command 4 Prepardness/Planning/Training 5 Medical Treatment/Injury 6 Equipment/Supplies 7 Cooperation/Multi Disciplinary 8 Psych 9 Zoning/Scene Safety 10 Staffing 11 Triage 12 Record keeping 13 Patient (flow/identification)/Distribution 14 Team Spirit 15 Roles														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Roccaforte et al. [35]	2001	x	x		x	x	x				x					
Martinez et al. [36]	2001	x	x	x				x		x	x	x		x		
Cook et al. [37]	2001		x	x		x				x	x	x		x		
Tamber et al. [38]	2001	x	x	x	x			x	x							
Simon et al. [39]	2001	x	x		x					x	x	x		x		
Mattox et al. [40]	2001	x	x		x			x			x			x		
Shapira et al. [41]	2002	x	x	x	x	x	x	x	x	x	x	x		x		x
Frykberg et al. [42]	2002	x	x	x	x	x	x		x	x		x	x	x		
Garcia-Castrillo et al. [43]	2003	x		x	x	x			x							
Shamir et al. [44]	2004	x	x	x		x	x	x			x	x		x		x
Einav et al. [45]	2004	x	x		x	x	x					x		x		
Almogy et al. [46]	2004	x			x	x	x				x					
Rodoplu et al. [47]	2004	x	x			x				x	x			x		
Kluger et al. [48]	2004	x		x				x			x			x		
Gutierrez de Ceballos et al. [49]	2005				x	x			x		x	x				
Kirschbaum et al. [50]	2005	x	x	x	x	x	x	x		x	x	x	x	x		
Aschkenazy-Steuer et al. [51]	2005	x		x	x	x	x	x			x	x		x		
Lockey et al. [52]	2005		x	x		x	x			x	x	x		x		
Hughes et al. [53]	2006	x	x		x		x	x					x			
Shapira et al. [54]	2006	x	x		x			x	x							
Aylwin et al. [55]	2006	x		x	x	x		x			x	x		x		
Mohammed et al. [56]	2006	x	x	x	x			x		x	x		x			
Bland et al. [57]	2006	x	x		x				x		x			x	x	
Leiba et al. [58]	2006	x		x	x	x	x				x	x		x		
Singer et al. [59]	2007	x	x	x	x	x	x	x	x	x	x	x		x		x
Schwartz et al. [60]	2007	x			x	x					x			x		
Gomez et al. [61]	2007	x	x	x		x	x	x			x					
Bloch et al. [62]	2007								x		x			x		
Bloch et al. [63]	2007	x	x		x						x	x		x		
Barnes et al. [64]	2007	x	x	x	x		x	x	x				x	x		
Carresi et al. [65]	2008	x	x	x	x	x		x			x	x	x			
Raiter et al. [66]	2008	x	x				x					x		x		

	Year															
Shirley et al.[67]	2008	x		x	x	x		x	x							x
Almgody et al. [68]	2008	x	x	x	x		x				x	x				
Turegano-Fuentes et al. [69]	2008	x	x				x			x	x	x	x			
Pinkert et al. [70]	2008	x	x	x	x					x		x				
Pryor et al. [71]	2009	x	x	x	x			x	x	x	x	x	x			x
Lockey et al. [72]	2012	x	x				x			x	x	x				
Sollid et al. [73]	2012	x	x				x			x		x		x		
Gaarder et al. [74]	2012				x	x	x	x	x			x		x		
NN et al. [75]	2013	x	x		x					x	x	x		x		
Jacobs et al. [76]	2013	x	x	x	x	x		x		x		x		x		
Gates et al. [77]	2014	x	x	x	x		x		x							
Wang et al. [78]	2014	x			x	x	x					x				
Ashkenazi et al. [79]	2014				x				x	x						
Thompson et al. [80]	2014	x	x		x	x	x	x								
Rimstad et al. [81]	2015	x	x	x	x											
Goralnick et al. [82]	2015	x	x	x			x	x							x	x
Hirsch et al. [22]	2015	x	x		x		x	x	x		x	x		x		
Lee et al. [83]	2016	x	x	x			x	x		x	x	x		x		x
Pedersen et al. [84]	2016	x				x		x		x		x		x		
Raid et al. [85]	2016	x	x	x	x		x	x	x		x	x				
Philippe et al. [24]	2016	x	x	x	x	x		x				x	x			
Traumabase et al. [86]	2016				x				x		x					x
Gregory et al. [87]	2016	x				x		x			x			x		
Ghanchi et al. [88]	2016	x	x	x	x						x	x			x	
Khorram-Manesh et al. [89]	2016	x	x	x	x	x	x	x	x			x	x	x		
Goralnick et al. [30]	2017	x	x	x	x	x		x			x				x	
Lesaffre et al. [90]	2017	x	x	x	x		x	x			x					
Brandrud et al. [91]	2017	x	x	x	x			x	x		x		x	x	x	x
Carli et al. [25]	2017	x	x	x	x	x	x	x	x	x		x	x	x		
Borel et al. [92]	2017	x	x	x	x	x	x	x			x	x	x	x		
Wurmb et al. [28]	2018	x	x		x			x		x		x	x	x		
Bobko et al. [93]	2018	x	x	x	x			x	x	x	x	x				
Chauhan et al. [94]	2018	x	x		x	x	x	x		x		x		x		
Hunt et al. [95]	2018	x	x	x	x	x	x	x	x	x		x	x	x	x	
Hunt et al. [96]	2018	x	x	x	x	x			x	x	x	x	x	x		
Hunt et al. [97]	2018	x	x		x			x	x				x			

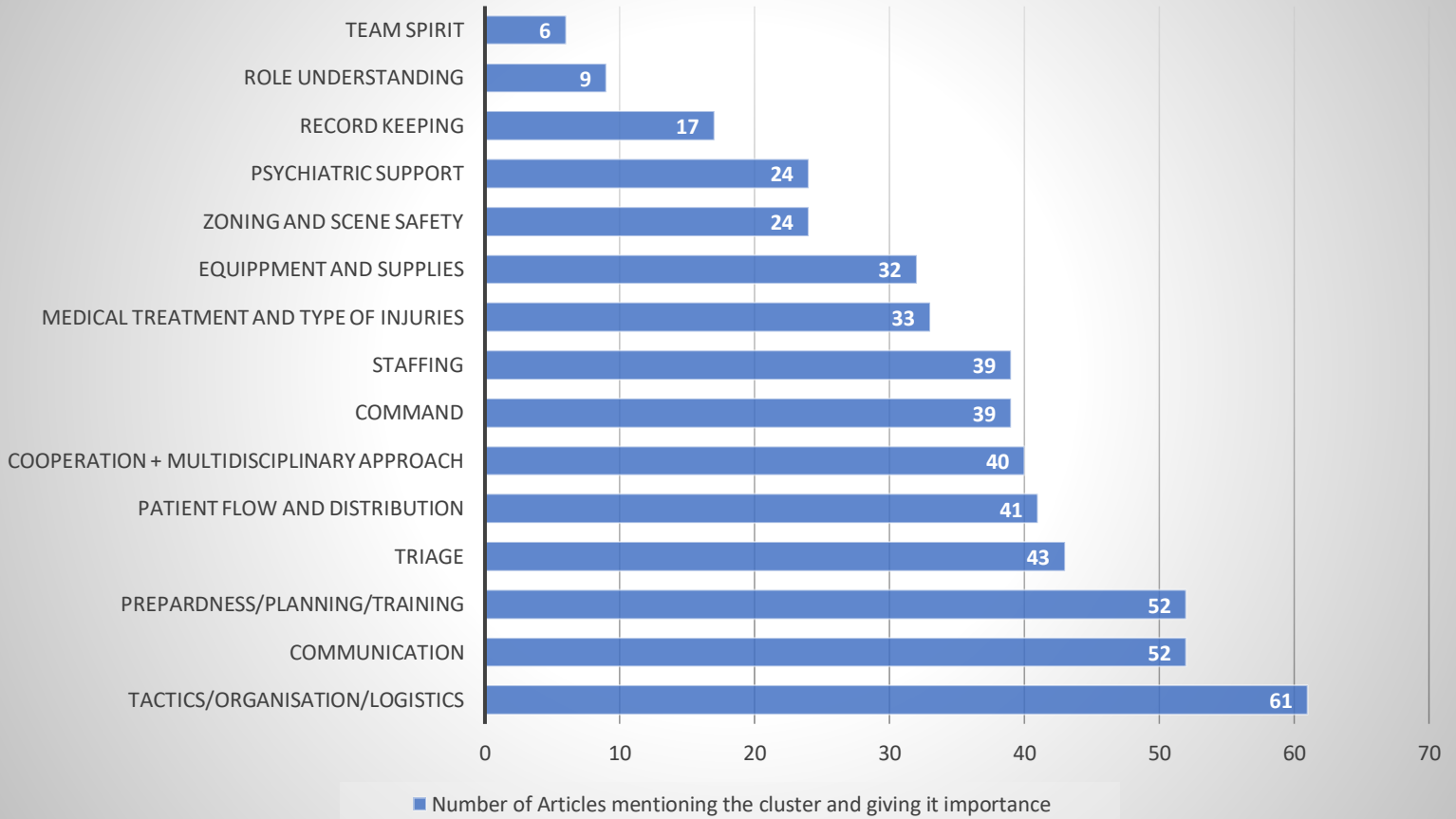*Table 4 – clusters mentioned per year*

35

Figure 9 – overarching clusters

The by far most important cluster was Tactics/Organisation/Logistics with 61 out of 68 articles mentioning it in some sort or form. Communication was mentioned in 52 articles and shared second place with Preparedness/Planning/Training while Triage was mentioned in 43. Similar importance was given to Patient Flow & Distribution, Cooperation & Multidisciplinary Approach, Command and Staffing with 41, 40, and two times 39 references accordingly. Medical Treatment & Type of Injury was mentioned in 33 articles while Equipment & Supplies featured in 32 articles. Zoning and Psychiatric Support were both mentioned 24 times while Record Keeping was noted in 17 articles. The two least mentioned clusters were Role Understanding and Team Spirit. (Figure 9)

Lessons Learnt

A total of 616 lessons learnt were assigned to the 15 overarching clusters. (Table 5) In order to guarantee optimal and complete information in the thematic sorting of lessons learnt, lessons that fit multiple clusters were assigned to each of the clusters accordingly. The numbers behind the lessons learnt indicate the articles that mentioned the specific lesson learnt. The counting uses the numbered PRISMA table as reference. Tactics/Organisation/Logistics was with 108 by far the cluster with the most lessons learnt followed by communication with 66 lessons learnt. Interesting to note, was the fact that, the numbers of lessons learnt did not necessarily correlate with the increasing numbers of articles in which a cluster was mentioned. (Figure 10) Even though Staffing was mentioned in 39 articles it generated only 38 lessons learnt whilst Medical Treatment + Type of Injury was only mentioned in 33 articles but generated 39 lessons learnt. This had two specific reasons. Reason 1 was that some in depth articles created multiple lessons learnt to a specific cluster so that a lot of information and lessons learnt could be extracted from a single article. Reason 2 was the fact that multiple articles formulated very similar, if not the same, lessons learnt so that these were grouped together as one even though they might have been mentioned in multiple articles.

Numbers of Lessons Learnt per Cluster

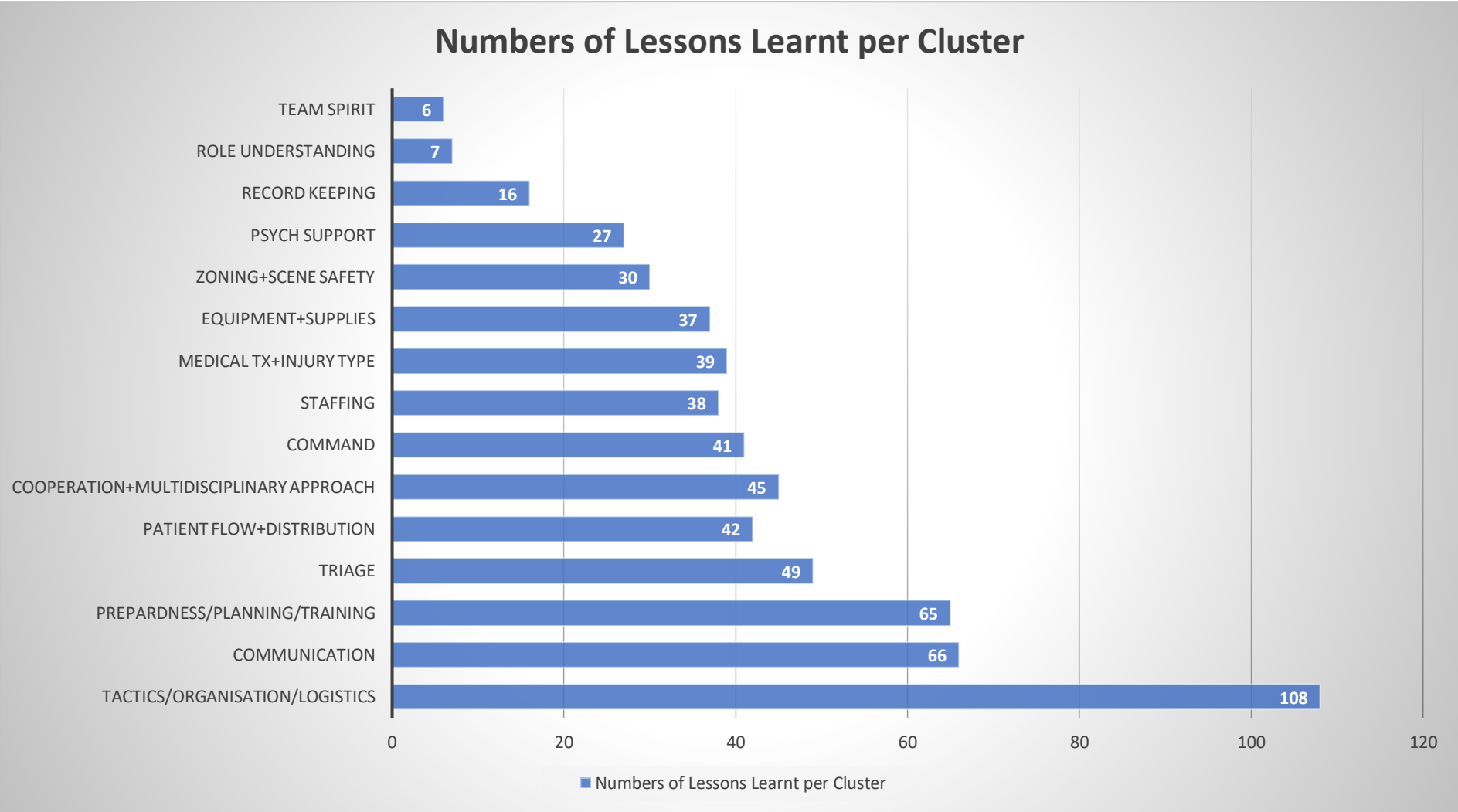| Cluster	Numbers of Lessons Learnt per Cluster
TEAM SPIRIT	6
ROLE UNDERSTANDING	7
RECORD KEEPING	16
PSYCH SUPPORT	27
ZONING+SCENE SAFETY	30
EQUIPMENT+SUPPLIES	37
MEDICAL TX+INJURY TYPE	39
STAFFING	38
COMMAND	41
COOPERATION+MULTIDISCIPLINARY APPROACH	45
PATIENT FLOW+DISTRIBUTION	42
TRIAGE	49
PREPARDNESS/PLANNING/TRAINING	65
COMMUNICATION	66
TACTICS/ORGANISATION/LOGISTICS	108

Figure 10 – numbers of lessons learnt per cluster

Lessons Learnt	Tactics/Organization/Logistics
1	Constant update on resources and limitation of all hospitals (5)
2	Need for solid disaster plan for each hospital (6)(30)
3	Have a national standard for major incidents and a preparedness concept/disaster response plan (39) (42) (43)
4	Adequate trauma centre concepts on national level (6)
5	Trauma leaders aware of bed capacities (6)
6	Updated disaster plans/drills (6)
7	Active pre-planned protocols - pre hospital protocol + hospital protocol (7)
8	All hospitals should be included in contingency planning (11)
9	Evacuation of the less critically ill to further away hospitals (11)
10	Use trauma guidelines (12)
11	Distance to hospital site major distribution factor (13)
12	Organisation of trauma teams that stay with a patient (14) (17)
13	Cancellation of all elective surgery/ Discharge of all non urgent patients (16)(34)(67)
14	Establish a public information centre close to hospital (20)
15	Detailed manual for potential terror attacks (20)
16	Do not base disaster plan on average surge rates (21)
17	Crowd Control (22)(25)(37)
18	Have an emergency plan even if not a level one trauma centre (26)
19	Prehospital and hospital Coordination + communication necessary (29)
20	Alert all hospitals (30)
21	Importance of access (31)
22	Standard Protocols but flexibility (1)
23	Avoid overcrowding in the ER (10)
24	Peri incident intensive care management - forward deployment (17)
25	Critical mortality reduced by rapid advanced major incident management (21)
26	Use ICU staff for Resus and Triage (33)
27	Standardisation in hospital incident planning (33)
28	Maximise Surge Capacity (35)(67)
29	Four Step Approach to terror attacks: analysis of scenario; description of capabilities, analysis of gaps, development of operational framework (36)
30	Empty hospital (37)
31	Establishment of various anti terror contingency plans (hijack/bombing/shooting) (43)
32	experienced personnel should treat patient and not take on organisation (44)
33	Activate contingency/emergency plans soon (14)(16)(44)(50)(51)(57)
34	Focus on increasing bed capacity especially ITU beds (16)(33)
35	Quick return to normality - ongoing care for normal patients (33)(49)(52)
36	Short transport times/ immediate access to OR save lives (46)
37	Good knowledge of major incident plans - quick activation (56)
38	Medical management and knowledge vitally important (57)
39	Activation of white plan - all hospitals/all staff/empty beds -> no shortage (49)(53)(63)
40	Early activation of surge capacity (61)(63)
41	Crucial interaction/communication between hospital/police/municipalities (61)
42	Avoid main gate syndrome - overwhelmed resources at the closest hospital (62)
43	Flexibility across sites/hospitals (67)
44	Increase trauma list capacity for weeks to come (67)
45	Limited mobilisation at remote hospitals (5)
46	Recruit help from outside early on (8)
47	Don't forget flexibility (8)(16)(27)(37)(38)(48)(64)
48	Combination of civil defence and emergency medical services (9)
49	Incident commander appoints: Liasion officer; public information officer; personnel officer; logistics officer; data officer; medical command officer; patient/family information officer (16)
50	No headquarter at frontline (5)
51	ABCD response":A ssess incident size and severity, alert B ackup personnel, perform initial C asualty Care, and provide D efinitive treatment (10)
52	Authority and command structure - two command posts – admin vs medical management (8)
53	Designated Treatment Area (31)
54	Med Students - Runners (1)
55	Tape fixed with name/specialty (1)
56	Delays should be expected (2)

57	Disruption in Transport - lengthens rescue effort (2)
58	Guidelines on biochemical warfare (4)
59	Mini Disasters as basis for escalation (flu season) (6)
60	Early debriefing (7)
61	Structural organisation important (19)
62	Rapid Scene Clearance - highly organised und efficient (8) (21)(23)
63	Clear well structured coordination (22)
64	Management of uninjured survivors and relatives – good communication (23)
65	Analysis based on past incidences (24)
66	Development of operational framework (24)
67	Assessment and re-evaluation of disaster plans (25)
68	ED as epicentre (25)
69	Most senior emergency physician directs traffic/surgeons overseas area - triage not by most senior personnel (25)
70	Combined activation of major incident plans (all EMS services) (30)
71	Vehicle coordination and rapid accumulation (31)(32)
72	Set principles rather than fixed protocols to allow for flexibility (32)(36)
73	Importance of quick evacuation (36)
74	Ambulance stacking area to allow access and reduce traffic jam (37)
75	Important to declare major incident asap (38)
76	Manage uncertainties and scene (38)(47)(52)
77	Coordination of rescue - especially HEMS (39)
78	Rapid logistical response (46)(55)(57)
79	Divide emergency response into stages, break into smaller parts (47)
80	Adaptation of decisions taken (47)
81	Early decision by incidence commander needed (47)
82	Volunteer surges difficult to manage but can be helpful (48)
83	Need to increase morgue facilities (56)
84	Improved alert system (56)
85	Clear communication, organization and decision making skills (58)
86	Robust and simple organisation and command (59)
87	Quickest possible return to normality (60)
88	Importance of evaluation and improvement of emergency plans (60)
89	Crisis management based on knowledge and data collection (61)
90	Fallback structures but flexibility and improvisation important (61)
91	Tactical management - get an overview and don't get stuck in details (61)
92	Prehospital damage control - military concepts in civilian setting (62)
93	Regional resource mobilisation vital (62)
94	Have a plan but use continuous reassessment and modification of response strategy (63)(66)
95	Use METHANE to assess incident (65)
96	Clear escalation plan (67)
97	Coordination and collaboration should be planned and practised at intra/inter-regional, multiagency and multiprofessional levels (66)
98	Improved forensic management (66)
99	Loggists important for operational strategic roles (66)
100	Maintaining access to other emergencies MI/Stroke etc (66)(67)
101	Gradual Deescalation – part of contingency plan (66)
102	Issue: Recognition of situational aspect and severity + complexity – evolving risk (66)
103	Cockpit view due to HEMS – helpful in big sweep of casualties (66)
104	Gaps in provision of rehab services - acute phase vs long term phase (68)
105	Access to legal and financial support for victims (68)
106	Clinical representation at strategic level to facilitate cooperation between networks/regions (68)
107	Support from neighbouring regions during terror (68)
108	Develop a network of capacities and capabilities which is constantly updated (68)
Lessons Learnt	**Communication**
1	Good overall communication crucial (1) (20)(27)(31)(32)(37)(39)(48)
2	Delays should be expected (2)
3	Radio Equipment vital as often all other communication lines lost (3)(16)(22)(30)(31)(35)(39)
4	Importance of reliable information (4)(50)
5	Effective intra-hospital communication (5)
6	Constant update on resources and limitation of all hospitals (5)
7	Better communication between disaster agencies (6)(42)

8	Importance of communication between different rescue teams (7)
9	Identification vests help communication and command structures – clear roles (7)
10	One point of intra and interhospital communication (7)
11	Importance of public communication centre (7)
12	Communication between disaster scene/EMS and hospital often big problem (8)(13)(16)(66)
13	Use of protected phone lines and walkie talkies (8)
14	Early information/communication from site to assess severity (10)
15	Early on radio/bleep system - later use of mobile phones possible (10)
16	Clear, well-structured communication and coordination (11) (22)(34)
17	Increase supplies through early communication with vendors (16)
18	Bleeps and cable phones as cell service often unreliable (17)
19	Multiple scenes create difficult command and communication problems (18)
20	Communication between rescue services vitally important (16)(19)(30)(60)(65)
21	Do not solely rely on mobile phones – collapse (20)
22	Establish a public information centre close to hospital (20)
23	Robust communication methods (7)(20)(37)(59)
24	Communication lines often fail (22)
25	Management of uninjured survivors and relatives – good communication (23)
26	Concentrate initially on relaying as much information as possible (25)
27	Important information: 1) the nature of the event 2) the estimated number and severity of casualties; 3) the exact location of the event; 4) the primary routes of approach and evacuation; 5) estimated time of arrival at the nearest hospital (25)
28	Use megaphones (25)
29	Turn off all non critical mobile cell phones during terror event (government implementation) (25)
30	Communication centre for relatives (16)(25)
31	No media inside hospital - media centre set up (25)
32	Importance of communication mechanisms during terror (30)
33	Communication with public - use of media (30)
34	Good telecommunication system - with backup options (32)(52)
35	Create Database of victims/casualties (35)
36	Importance of communication/coordination between incident site and hospitals (29)(35)(37)(41)(63)
37	Importance of even distribution between hospitals – communication (36)
38	Early press briefings to stop hysteria (37)
39	Communication failure will always happen (38)
40	Good care despite communication failure - hence senior well-trained personnel (38)
41	Communication-use of standardised operational terms (42)
42	Terror awareness - train the public – communicate (43)
43	Good intrahospital communication between specialties (46)
44	Decision making without all information - lack of communication unavoidable (47)
45	Public Reassurance through good communication (49)
46	Restricted internet access to avoid breakage (50)
47	Communication with relatives (52)(63)(67)
48	Better communication of patient information between prehospital and hospital setting (53)
49	Communication channel between police, EMS and hospitals (53)
50	Improved alert system (56)
51	Public relations and communication (56)
52	Readiness of hospitals - good communication and preparation (57)
53	Mutual communication systems (57)
54	Public engagement and empowerment - communication and teaching (58)
55	Clear communication, organization and decision making skills (58)
56	Better Integration of operators of different rescue chains + communication (59)
57	Provide patient lists to police to ease communication/information gathering for relatives (61)
58	Importance of patient hand over communication (61)
59	Effective communication - improve information sharing (67)
60	Sharing of corporate knowledge – communication of information (66)
61	Good communication and situational awareness – use liaison officers (66)
62	Media policy and communication – robust and well informed (66)
63	Consider radio control mechanisms (66)
64	Confidentiality when it comes to communication with media (68)
65	Security and Privacy issues when it comes to media communication (68)

66	Quick and clear communication with relatives - to avoid information gathering via social media (68)
Lessons Learnt	**Preparedness/Planning/Training**
1	Practise/Drill – important! (1)(6((8)(20)(25)(33)(43)(56)(57)(63)
2	Terror awareness - train the public (4)(43)(65)
3	Trained prehospital personnel is a crucial factor (5)
4	Update disaster plans – train them (6)(49)
5	Different sort of drills to prepare (manager drills/full scale drills) (7)
6	Training is most important (8)(20)(21)(42)
7	Have and follow a pre-existing plan - based on experience (8)
8	Thorough good quality Preparation (8)(20)
9	Good prehospital care systems improve survival (8)
10	Training of triage to reduce over and undertriage (8)
11	Debrief early and in a structured way (8) (10) (17) (23)(52)(67)
12	Preparation for incidents and injury types (9)
13	Be prepared: have 1-3months supply of surgical disposables (10)
14	All hospitals should be included in contingency planning (11)
15	All hospitals should be prepared to act as evacuation hospital - drills and training (11)
16	Importance of damage control concepts - training (12)
17	Cancellation of all elective surgical procedure (15)
18	Emptying of ICU and wards (15) (21)
19	Importance of planning, coordination, training, financial support and well equipped medical services (15)(16)
20	Clear out hospital during latent phase (17)
21	Have a major incident plan - have it rehearsed (22)(16)(37)
22	Analysis based on past incidences (24)
23	Analysis of gaps between scenario and response needed (24)
24	Pre-event preparedness crucial - extensive planning improve outcome (25)
25	Train core of nurses in Emergency Medicine Skills (25)
26	Have an emergency plan even if not a level one trauma centre (26)
27	Rehearsal of emergency plan (26)
28	Every hospital should be prepared for a major incident with terrorist background -solid emergency plans in situ (29)(30)
29	Importance of thorough analysis and short fallings (31)
30	Good mix between planning and improvisation (31)
31	Major incident plan necessary - on a local as well as regional level (33)
32	Meticulous planning (33)
33	Extensive education (33)
34	Regular Review (33)
35	Emergency and Disaster Preparation and Planning is crucial (19) (36)(41)(46)
36	ALL hospitals should be ATLS trained and have Major incident drills (36)
37	Regional major incident plan to help allocate resources (40)
38	Have and Activate contingency plans soon (44)
39	Be prepared for uncertainty and unsafe environment (45)(47)
40	Having experience best preparation for next incident (47)
41	Training saves lives (49)
42	Drills based on past experiences (52)
43	Teaching/Training/Education - best preparation (53)
44	Disaster training best preparation for reality - systematic multidisciplinary training/drills (54)
45	Train for new pattern of injuries (57)(59)
46	Readiness of hospitals - good communication and preparation (57)
47	Public engagement and empowerment - communication and teaching (58)
48	Staff training in combat medicine -cooperation with the military (58)
49	Greater investment, integration, standardisation of disaster medicine (58)
50	Rapid standardised ways to distribute lessons learnt - so plans can evolve (58)
51	Multidisciplinary training - incl police/fire service (60)(64)(65)
52	Monthly multidisciplinary trauma training (61)
53	Train the public/police in first aid/bleeding control (60)
54	Importance of evaluation and improvement of emergency plans (60)
55	Emergency preparedness based on planning/training/learning (61)
56	Competence through continuous planning/training/drills (61)
57	Cooperation: Teaching of medical staff by military (57) (62)
58	Teaching of trauma management to med students (62)
59	Improve Tx of paediatric cases – training (62)

60	Anticipation and planning - Plan Blanc obligatory (63)
61	Awareness of tactical threat - idea of hazardous area response team (65)
62	Training in Trauma Management (67)
63	Planning and training – the value of organised learning (66)
64	National process for debriefing and lessons learnt (66)
65	Regional standards for training (68)

Lessons Learnt	Command
1	Strict command and control structures with designated hierarchy (1) (4)(27)(31)(34)(66)
2	Establish incident command system/centre – important (3)(16)(63)(50)
3	Early command and control structure - be prepared to rebuild (4)
4	Avoid improvisation in command structure (7)
5	Identification vests help communication and command structures – clear roles (7)
6	Most senior medical officer = commander (7)
7	Prompt and vigorous leadership (8) (22)
8	Civil Defence coordinates and has overall command – clear structure (9)
9	Importance of chain of command (10)(17)
10	Command structures - medical director vs administrative director (14)
11	Incident commander appoints: liaison officer; public information officer; personnel officer; logistics officer; data officer; medical command officer; patient/family information officer (16)
12	Chain of command: most senior official from all important specialties plus hospital admin (17)
13	Multiple scenes create difficult command and communication problems (18)
14	Have experienced decision maker (21)
15	Command and control – regular trauma meetings (22)
16	Importance of EMS Command Centre (24)
17	Accept chaos phase - command structures will follow (25)
18	Importance of local command structures – most senior official = commander in chief (25)
19	Communication/Cooperation between managers of different EMS (30)
20	Work within established command and control structures (30)(42)
21	Clear distinction between command/control and casualty treatment(33)
22	Lead by senior clinicians (34)
23	Effective decision making – command (36)(43)
24	Command structures need to be robust (37)
25	EMS command structure (37)
26	Dual command -ambulance/tactical commander vs medical commander (47)
27	Command and control vs collaboration – both important (48)
28	Flexible leadership (48)
29	Leadership through ER Physicians (50)
30	Central Command - Health emergencies crisis management centre (52)
31	Central command in hospital - director of medical operations (53)
32	Good crisis management/command important (56)
33	Multidisciplinary Management (57)
34	Clear communication, organization and decision making skills vital (58)
35	Robust and simple organisation and command (59)
36	Crisis management based on knowledge and data collection (61)
37	Solid command structures and leadership based on experience and knowledge (61)
38	Tactical management - get an overview and dont get stuck in details (61)
39	Leadership/Coordination through experienced healthcare professionals (62)
40	Tactical command post in safe zone (64)
41	Surgeon Commander for coordination and prioritisation (67)

Lessons Learnt	Triage
1	Priority - quick Triage -> Transport to Hospital (2)
2	Multiple Triage areas - staff with freelancers (2)
3	Establish Casualty Collection Points/Triage simple and early (3)
4	Coloured tags for triage (3)(7)(25)
5	START System - Simple Triage Rapid Treatment (3)
6	Doctors not in red zone -triage in safe zone (5)
7	Triage by most senior personnel (7) (15) (18)
8	Triage according to ATLS (7)
9	Systematic planning for orderly triage, stabilisation and evacuation to hospital through chain of treatment stations (8)
10	Triage at a distant site to disaster (8)
11	Importance of triage - good triager - absolute authority (8)

12	Small medical teams for 2nd triage (8)
13	Senior general surgeon triages at hospital entrance (10)
14	Triage on arrival at hospital entrance as prehospital triage not necessarily reliable (1)(17)(10)(16)(53)
15	Rapid primary triage- evacuation of the critical ill to nearest hospital (evacuation hospital) for stabilisation (11)
16	Beware of undertriage (11)
17	Importance of triage at incident site (13)(51)
18	Importance of Retriage (at hospital) (14)(49)(56)(63)(67)
19	Importance of triage concepts in general – avoid undertriage (14)
20	Primary survey through surgeons and anaesthetists (15)
21	Diligence in Triage (15)(40)
22	Large amount of over triage - no negative consequences/Overtriage does not kill (15)(21)
23	Establishment of triage areas in hospital (16)
24	Tertiary survey day after (17)
25	Repeated effective triage maintains hospital surge capacity (21)
26	Idea of triage hospital (24)
27	Rapid primary survey and triage - delay of secondary survey (25)
28	Most senior emergency physician directs traffic/surgeons overseas area - triage not by most senior personnel (25)
29	Prehospital as well as hospital triage vitally important (29)
30	Importance of good primary Triage (31)(32)(36)(60)
31	Frequent reassessment and triage (34)(40)
32	Quick triage - scoop and run - repeated triage at hospital (35)
33	Quick effective good basic triage - reduction of overtriage (37)(42)(57)
34	Improved triage through physician/paramedic teams (38)
35	National triage guidelines (38)
36	Enough equipment but mainly quick triage and transport (39)
37	Deliberate overtriage (40)
38	Directed quick patient flow to relieve triage area (41)
39	Inadequate triage results in critically injured patients - retriage is vital (44)
40	Outside triage area – not in hospital (50)
41	Triage: absolute vs relative emergencies (52)
42	Crisis teams to organise triage (57)
43	Continuous retriage – similar triage system preclinical and in hospital (57)
44	Improve triage skills (62)
45	Triage outside hot zone - no Tx in hot zone if not trained (64)
46	Triage according to 3 ECHO - coloured cards (65)
47	Reproducible triage standards (67)
48	Casualty disposition framework with an effective enhanced triage process (66)
49	Most important triage point: able to walk vs not able to walk (66)
Lessons Learnt	**Staffing**
1	Descale asap -> Rest time for staff (1)
2	Staff Safety major concern (2)
3	Freelancers - difficult to manage (2)(37)
4	Multiple Triage areas - staff with freelancers (2)
5	Trained prehospital personnel (5)
6	Quick response - Increase staffing asap (5) (10)(25)(26)(27)(29)(34)(37)(55)(56)(63)
7	Staff imprints lessons from mini-diseasters and use this experience (6)
8	Too few nurses - improve incentives (6)
9	Maximal increase of staffing needed – most important factor (7)
10	Forward deployment of anaesthetist – allows for continuity of care (10)
11	Uptodate list of available staffing important (10) (17)
12	Relieve staff after 8-12h for breaks (10)(17)(63)
13	Optimise utilisation of manpower and supplies (12)
14	Primary survey through surgeons and anaesthetists (15)
15	Establishment of human resource pools - esp with volunteers (16)
16	ED staffed with nurse/doctor combo @ each bed (16)
17	Gather information and personnel during latent phase (17)
18	Helicopters to transport staff and equipment (18)
19	Triple: anaesthetist trauma surgeon abdominal surgery lead assessment and allocation to definite care (21)
20	Efficient Staff Allocation (22)
21	Pre Hospital Physicians useful (23)
22	Description of relevant capabilities of medical system (24)

23	Using tags for triage - no resuscitation efforts until enough staffing (25)
24	Train core of nurses in Emergency Medicine Skills (25)
25	Different specialties (ENT/psych) needed (28)
26	Spread out teams to attend more patients (31)
27	Too much staff available in ER – overcrowding (35)
28	Good care despite communication failure - hence senior well trained personnel (38)
29	Triage by senior medical officers (39)
30	Keep track of staff showing up (41)
31	Keep personnel in reserve/on standby (49)(50)(52)
32	Follow up on personnel - psychological and physiological (52)
33	Experienced staff vitally important (54)
34	Staff training in combat medicine - cooperation with the military (58)
35	Surge in equipment and staff vital (59)(61)(63)
36	Safety of personnel - idea of SWAT paramedics - Tx under fire (64)
37	Increase blood bank staff (67)
38	Photography staff/service to document injury (67)
Lessons Learnt	**Patient Flow and Distribution**
1	Majority Survivors self-rescuer (2)
2	Establish Safe Way for self-rescuer/non invalid patients (3)(51)
3	Increase ICU Capacity move patients/unlock new areas(5) (10)
4	Patient flow - division between different hospital to avoid overload/right pt to right hospital (6)(7)
5	Fast forward flow (8)
6	Leap frogging - distribution of casualties to hospitals (8)
7	Log of most severely injured patients and their whereabouts (10)
8	Quick redistribution of patients to clear ER for new ones (10)
9	Use recovery room for monitoring unstable patient (10)
10	Second wave of patient transfer between hospitals to avoid resource overstretching (11)
11	Maldistribution between hospitals huge problem (13)
12	Unidirectional patient flow – quick emptying of ED - one way pathway of care (14)(16)(49)(55) (57)(61)(63)(67)
13	Walking wounded redirected to satellite areas (16)
14	Early evaluation of patients by senior doctors - early estimation of ICU capacity/operating capacity needed (17)
15	Transport off ICU or to different hospitals needs to be thought of (17)
16	Rapid removal from critically ill patients out of an unsafe environment (18)
17	Transferring patients rapidly to definite care – rapid scene clearance (21)(22)(60)
18	Need for secondary transport (interhospital) (24)
19	Distinction between circle 1 and circle 2 hospitals - direction of casualties accordingly (24)
20	Quick evacuation of casualties - if stable enough severely injured pt to trauma Hx (25)
21	ED as epicentre - clear ED quick (25)
22	Different areas: fast track, psychiatric, major trauma etc (25)
23	Primary Evacuation of mildly injured patients to distant hospitals (26)
24	Treat patient in Trauma 2 Centre and only transfer if necessary to Trauma Level 1 centre (26)
25	Large number of mildly injured patients need to be expected and swiftly dealt with (28)
26	Divert non urgent patients to hospitals further away from incident site (29)
27	Survivor reception centres to alleviate hospitals (30)
28	Primary and balanced distribution between hospitals (32)(36)
29	Timely evacuation out of unsafe zone (32)(42)
30	Overload of patients at close by hospitals – huge problem (35)
31	Fast track route for minor injuries (37)(40)
32	Patient flow - evacuation to cold zones; no rescue in unsecure area (39)
33	Enough equipment but mainly quick triage and transport (39)
34	directed quick patient flow to relieve triage area (41)
35	Secondary patient flow according to capacity and specialty (49)
36	Relocation of current patients (50)
37	Cooperation between hospitals and trauma centres - recognise your limits and transfer (61)
38	Patient Tx/Flow: Tourniquet use und quick transfer to definite care (62)
39	Track patients through hospital - difficult task (63)
40	Casualty clearing station - part of patient flow (65)
41	Casualty disposition framework with an effective enhanced triage process (66)
42	Safe transfer and handover of existing patients (66)
Lessons Learnt	**Cooperation and Multidisciplinary Approach**

1	Simultaneous Search/Rescue/Treatment (2)
2	Common goal/benefit (4)
3	Better communication between disaster agencies important (6)
4	Importance of communication between different rescue teams (7)
5	Especially trauma patients need teamwork/good cooperation (surgery/anaesthetic) (10)
6	Cooperation of the entire medical system - prehospital as well as hospital (14)
7	Increase supplies through early communication with vendors (16)
8	Collaboration with police to deliver supplies (16)
9	Police command centre within hospital (16)
10	Chain of command: most senior official from all important specialties plus hospital admin (17)
11	Cross organisational planning important (19)
12	Communication between rescue services vitally important (19)(37)
13	Good teamwork is crucial (20)
14	Triple: anaesthetist trauma surgeon abdominal surgery lead assessment and allocation to definite care (21)
15	Multidisciplinary Meetings (22)(66)
16	Most senior emergency physician directs traffic/surgeons overseas area - triage not by most senior personnel (25)
17	Flexibility of services important - interaction/cooperation important (27)
18	Possibility for emergency services to cooperate and communicate (30)
19	Combined activation of major incident plans (all EMS services) (30)
20	Joint field command post (31)
21	Cooperation and Communication between hospitals and all emergency services (33)
22	Dual surgical command-triage (40)
23	Cooperation between police and EMS (42)
24	methodical multidisciplinary care delivery (46)
25	Command and control vs collaboration – both important (48)
26	good cooperation/collaboration between services vital (49)(50)
27	Good interdisciplinary cooperation vital (50)
28	Communication channel between police, EMS and hospitals (53)(62)
29	Multidisciplinary care saves lives (55) (57)
30	Staff training in combat medicine - cooperation with the military (58)(62)
31	Cooperation between EMS and police/fire services (60)
32	Multidisciplinary training – incl. police/fire service (60)(64)(65)
33	Multi-professional networks/interaction incl. Mental Health (61)
34	Cooperation between hospitals and trauma centres - recognise your limits and transfer (61)
35	Crucial interaction/communication between hospital/police/municipalities (61)
36	Provide patient lists to police to ease communication/information gathering for relatives (61)
37	Good communication between incident site and hospital (63)
38	Law Enforcement Medical Commander - cross over between specialties/cooperation (64)
39	Awareness of tactical threat - idea of hazardous area response team (65)
40	Cooperation between civilian rescue teams and military (57)(62) (66)
41	Sharing of corporate knowledge – communication of information (66)
42	Good communication and situational awareness – use liaison officers (66)
43	Coordination and collaboration should be planned and practised at intra/inter-regional, multiagency and multi-professional levels (66)
44	Clinical representation at strategic level to facilitate cooperation between networks/regions (68)
45	Support from neighbouring regions during terror (68)
Lessons Learnt	**Equipment and Supplies**
1	Functioning Equipment (Broadband Internet) (1)
2	Asset/Resource evaluation (7)
3	Combat care - reduced level of treatment per patient due to resource insufficiencies (7)
4	Restrict laboratory and radiology testing (8)(40)
5	Protection of medical assets (8)
6	Need for appropriate equipment + supplies (10)(65)
7	Increase equipment - prep minor OR for major casualties (10)
8	Increase supply of available blood products (10)
9	Rapid primary triage- only evacuation of the critical ill to nearest hospital (evacuation hospital) for stabilisation - to avoid resource overstretching (11)
10	Second wave of patient transfer to avoid resource overstretching (11)
11	Optimise utilisation of manpower and supplies (12)

12	Increase supplies through early communication with vendors (16)
13	Collaboration with police to deliver supplies (16)
14	Mobile multiple casualty carts/disaster supply carts with equipment are helpful (17)(50)
15	Assess Need for chemical and radiological monitors
16	Helicopters to transport staff and equipment (18)
17	Basic equipment important and needed (19)
18	Description of relevant capabilities of medical system (24)
19	Use megaphone (25)
20	Protective personal equipment (25)
21	Mobile mass casualty vehicles with additional supplies (25)(66)
22	Supply chains need to be reliable/organised well (27)
23	Use of radio systems (30)(39)
24	Increase and storage of supplies (30)
25	Basic first aid kits on buses/trains (30)
26	Allocation of resources difficult especially with multiple incidents (38)
27	Enough equipment but mainly quick triage and transport (39)
28	Regional major incident plan to help allocate resources (40)
29	More advanced equipment incl CBRN (43)
30	Allocate resources to correct diagnosis (44)
31	Extensive use of tourniquet (46)(62)
32	Challenge of technology-equipment may fail (48)
33	Back up resources - mobilise equipment and staff (52)
34	Use of clotting devices/tourniquet (57)
35	Surge in equipment and staff vital (59)(63)
36	Avoid main gate syndrome - overwhelmed resources at the closest hospital (62)
37	Regional resource mobilisation vital (62)
Lessons Learnt	**Medical Treatment + Type of Injury**
1	Rapid Treatment important (3)
2	START System - Simple Triage Rapid Treatment (3)
3	Combat care - reduced level of treatment per patient due to resource insufficiencies (7)(11)
4	Early aggressive resuscitation predicts survival (8)
5	Available surgical capacity needs to be increased (8)
6	Use critical mortality rate as indicator for assessing medical care (8)(21)
7	Restrict laboratory and radiology testing – minimal investigations (8)(21)(40)
8	Evacuate Patients as soon as possible (8)
9	Only damage control surgery – the rest must wait (8)(53)
10	Medical treatment dependent on type of attack (9) (12)
11	Rapid provision of definite care (9)
12	Terror attack cause different/specific injury patterns (10)(66)
13	Tx according to ATLS guidelines (11)(25)
14	Many blast injuries (13)
15	Predominance of minor injuries during terrorist bombings (secondary/tertiary blast effect) and worried well patients (15)(24)
16	Critical injury often roughly 1/3rd (15)
17	BLI often immediate death - if not often in combo with ear injury (15)
18	Only 5% ISS >15; 2% ISS>25 (16)
19	Main injuries: blunt trauma, blast injury, penetrating wounds, burns (17)
20	Average ISS Score of ICU admission 24 (17)
21	Rapid removal from critically ill patients out of an unsafe environment - scoop and run Tx (18)(24)
22	Damage Control Treatment and Mind Set to increase surge capacity (21)
23	Using tags for on scene triage - no resuscitation efforts until enough staffing (25)
24	Treat patient in Trauma 2 Centre and only transfer if necessary to trauma level 1 (26)
25	professional abilities are important (27)
26	Damage Control Treatment – no provision of individual definite care (25)(31)(33)(40)(63)(67)
27	ATLS/PHLTS Standards (42)
28	TCCC + Haemorrhage Control (42)(49)(51)(57)(65)
29	Roughly 10% suffer major injury (44)
30	Operations according to urgency (44)
31	Extensive use of tourniquet (46)(57)
32	Immediate access to OR (55)
33	Train for new pattern of injuries (57)
34	Medical management and knowledge vitally important (57)

35	Stop the bleeding - tourniquet use – train as basic first aid (58)
36	Integration of TCCC to ATLS (58)
37	Improve Tx of paediatric cases – training (62)
38	Patient Tx/Flow: Tourniquet use und quick transfer to definite care (62)
39	Safety vitally important - extent of Tx based on situational safety (65)
Lessons Learnt	**Zoning and Scene Safety**
1	Security at all hospital entrances - lockdown (1)(16)(41)(50)
2	Simultaneous Search/Rescue/Treatment – beware of security risks of this concept (2)
3	Scene Safety/Scene Control - beware of loss of rescue personel - safety first (2)(37)
4	Beware Second hit principle - protect trained personnel (2)(8)(37)
5	Establish Safe Way for Self Rescuer (3)
6	Doctors not in red zone -triage in safe zone (5)(25)
7	Safety of staff paramount (7)
8	Rapid removal from critically ill patients out of an unsafe environment (18)
9	Scene Safety – important but huge problem hence rapid evacuation (13) (18)
10	Full personal protective equipment and knowledge of the prehospital environment helpful (18)(25)
11	Awareness for explosive devices being carried into hospital (22)
12	Continuous assessment of scene safety (25)
13	Safety first - triage/command outside danger zone (37)(38)
14	Manage uncertainties and scene (38)
15	Evacuation problematics due to scene and geographical environment (39)
16	Importance of scene safety and terror control (45)(60)
17	Scene safety – Secondary attack/Collapsing buildings/explosive Device (45)
18	Conventional rescue teams out of danger zone (51)
19	Operating capacity within on scene dressing station-tactical physicians as concept (51)
20	Scene Safety - Zoning (exclusion zone) (51)
21	Scene Safety: Develop best compromise btw safety of responders, immediate care and fast extradition (62)
22	Beware of hospitals being soft targets (62)(67)
23	Safety of personnel - idea of SWAT paramedics - Tx under fire (64)
24	Triage outside hot zone - no Tx in hot zone if not trained (64)
25	Tactical command post in safe zone (64)
26	Awareness of tactical threat - idea of hazardous area response team (65)
27	Scene Safety can't be guaranteed (65)
28	Safety vitally important - extent of Tx based on situational safety (65)
29	Challenges of being in the hot zone – multifaceted and continuously evolving (66)
30	Issue: Recognition of situational aspect and severity + complexity – evolving risk (66)
Lessons Learnt	**Psychiatric Support**
1	Early psych help important (4)(68)
2	Site for acute stress disorder Tx needed (7)
3	Good psychological support necessary and important (8)(15)(40)(52)
4	Importance of post-traumatic stress disorder treatment groups (9)
6	Don't underestimate the psychological and physical effects on health care workers (20)
7	Psychological support for emergency services/healthcare worker/staff (23)(33)(52)(66)
8	Debriefing as stress relief (25)(68)
9	Psychiatric support before discharge for all patients (25)
10	Psychological support for mildly injured patients (28)
11	Set up survivor groups/psychological support (30)
13	Psych support to reduce long term impact of terrorism (43)(61)
14	Establishment of mental health counselling for staff (43)
15	Psychiatric illness as hazard for emergency personnel (45)
16	Psychological support centre (49)
17	Low PTSD with good preparation, debriefing and high role clarity (54)
18	Psych follow up for staff and patients (57)(67)(68)
19	Multi-professional networks/interaction incl. Mental Health (61)
20	EVERYONE is seen by psych! (61)
21	Psychological care - Increase psych support short and long term (62)
22	1/3 of victims develop PTSD! (62)
23	Psych support - informal and formal Treatment (64)
24	Improve bereavement support (68)
25	Psychological first aid approach incl. self help (68)
26	Bereavement nurses - 24/7 access in the first 48h (68)
27	Monitor high risk groups of PTSD (68)
Lessons Learnt	**Record Keeping**

	1	Written documentation strapped to patient (8)
	2	Early start of data collection (16)
	3	Good Record Keeping essential (19)(22)(31)(37)
	4	Lead agency to SOLEY deal with record keeping (30)
	5	Importance of data collection of casualties at the scene (30)
	6	Importance of documentation - which patient has already been triaged (31)
	7	Create Database of victims/casualties (35)
	7	Identification difficulties of victims - improve documentation to allow quicker identification (53)(57)(63)
	8	Better communication of patient information between prehospital and hospital setting (53)
	9	Detailed documentation of the disaster operation (60)
	10	Crisis management based on knowledge and data collection (61)
	11	Improvement in identification: Interpol Disaster Victim Identification Standard (62)
	12	Track patients through hospital - difficult task (63)
	13	Standardised documentation at regional level/ Need for national casualty identification system (67)
	14	Photography staff/service to document injury (67)
	15	Patient identification difficult task – standardized identification and documentation systems (66)
	16	Importance of patient identification to allow for family reunification/bereavement (68)
Lessons Learnt	**Role Understanding**	
	1	Clear identification methods of roles – tags/vests – helps communication and command structures (7)(25)(50)
	2	Dedicated roles with clear defined duties during event - command and control physician; discharge/ patient flow organiser; ED supervisor (10) (33)(50)
	3	Assigned roles in disaster plan (37)
	4	Flexibility but clear roles (48)
	5	Know your capabilities/professional role (54)
	6	Low PTSD with good preparation, debriefing and high role clarity (54)
	7	Clear defined roles help to give security and confidence and improve outcome (61)
Lessons Learnt	**Team Spirit**	
	1	Keep team spirit up (23)
	2	Form coalition to keep up spirit and improve (48)
	3	Staff solidarity and professionalism vital 56)
	4	Public engagement and empowerment - communication and teaching (58)
	5	Professionalism and Team Spirit important for success (61)
	6	Mutual support important (66)

Table 5 – lessons learnt

Discussion/Interpretation Part I

The 15 overarching clusters helped organise the 616 lessons learnt and brought structure to the flood of information. Within the discussion part of this paper, the various lessons learnt per cluster will be outlined, discussed and put into context. The papers mentioning the specific lessons, will be added within the text to allow for prompt and easy identification. It is obvious that a few lessons in each cluster have overwhelming support within the literature whilst others have only been mentioned a few times. However, it also seems that the lessons mentioned multiple times are often far less concrete than the ones that have only been mentioned in a few articles. It also seems that many of the identified lessons are of general nature and are based on common sense. However, very often it is common sense and a general overview that is the most difficult to maintain during a chaotic situation such as a terror attack which is why the importance of these formulated lessons cannot be overestimated.

Tactics/Organisation/Logistics

The cluster of tactics, organisation and logistics was mentioned in 61 out of 68 articles and was hence the most mentioned cluster overall. Within the cluster the main point was the quick naming of the incident as a mass casualty event with terror background and the quick and adequate activation of the right contingency and emergency plans and a rapid logistical response.[48,50,79,83,84,89,87,80,22,24,92,88,72] Whilst pre-planned and practised tactical concepts are vital to successfully deal with terror attacks, many articles mentioned the need for flexibility in the execution of pre-established plans due to the vast differences in circumstances during terror attacks. Hence, last minute adaptations and correct on-site situational judgement will almost always be necessary.[15,42,50,61,71,72,30,93,36,66,70,81,85,96,91] The timely evacuation of casualties out of the danger zone and their distribution to hospitals was another important topic and included a rapid surge in transport capacity, constant update on resource limitations and bed capacities of hospitals and an organised distribution of casualties to different hospitals.[36,42,52,55,57,39,40,70,65,66] In order to achieve this and avoid the main gate syndrome of swamping the closest hospital, all hospitals need to be alerted and need to have contingency plans in situ to allow for a rapid response especially as one tactic

could be to transport less injured patients to smaller hospitals further away.[45,47,60,39,40,64,25] In the same way that there was a focus on a rapid mounted response, many articles also pointed to the necessity of a quick return to normality in order to allow for rest and the continuous provision of other emergency services. [22,67,91,95,96,86,85] Hospitals should focus on surge capacity, provision of good triage and early access to operating theatres and increasing ICU/operating capacities by cancelling elective surgeries and increasing possible discharges.[44,80,48,50,96,68,51,95,71] The cycle of improvement after a terror attack, starts with good and early debriefing, incorporating the possible improvements, updating guidelines and national standards and training them on regional, supra-regional and national levels to improve coordination and develop a network of capabilities.[40,41,46,58,59,67,56,70,73,76,77,28,95-97,91] This helps structural organisation and incident management.[54,90,53,30,55,91] Incorporating military concepts, improved alert systems, combined incident plans, coordination of rescue through HEMS as well as using concepts such as METHANE for reporting and recognition of the various risks are all factors that need to be considered and could improve outcome.[25,94,88,95,64,73,43] The importance of a structured ABCD (Airway/Breathing/Circulation/Disability) approach, forward deployment, a clear distinction between medical and administrative management, well-trained personnel and good triage, good communication between incident site and hospital, crowd control through public information and continuous situational reassessment should not be underestimated. [42,51,63,71,59,54,44,78,81,95,89,48,50,92] Having the headquarters for such logistics within the safe zone is of course vital.[39] In the long run financial support for victims and increase rehabilitation options must be considered.[97] Many of the lessons learnt in all other clusters could of course also be placed within the Tactics and Organisation cluster, hence the focus of this discussion was on the more general lessons and concepts that are not discussed in depth elsewhere.

Communication

Communication and all its different aspects were given a lot of attention. Even though many different lessons learnt were formulated, the most mentioned one was the simple fact that communication is the most crucial factor for a successful medical rescue operation post terror attack.[35,66,71,54,73,61,82,65,30] Special focus ley on communication between the primary site of attack with the different hospitals to allow for information

gathering, assessment of needed surge capacity, even distribution of casualties, preparation and continuity of care.[42,47,71,44,69,24,70,28,50,89,63,92,75,91] The other important focus was on good communication and communication structures between all the different rescue services involved including police, fire brigade and emergency medical services.[40,64,76,50,53,94,90,24,41,28,22,96,54,59,71,57,92] Multiple sites of attack naturally worsen communication problems and even better alert systems need to be developed.[52,88] Another point mentioned was a clear and early on communication with the wider public and concerned relatives in order to reduce panic and anxiety and allow for a coordinated rescue operation to take place without endangering and disrupting the public life more than necessary.[6,41,54,64,71,22,88] The role and power of the media as well as social media channels and the balance between confidentiality issues and the need to calm the public should always be considered.[95,97,22,88] One of the biggest technical issues described in many of the articles, was the complete overload of phone networks which led to the breakdown of communication by phone. Having backup channels such as radio communication proved to be helpful in multiple situations.[37,50,56,64,65,69,73] Reverting to simple methods such as megaphones and bright vests or making executive decisions to turn off all non-essential mobile phones and restrict internet access are two extreme ends of dealing with the same problem.[83,59,95,41] Good communication is not only important between main actors. Early communication with vendors to increase supplies, good inter-hospital communication for secondary transfer of patients and constant resource updates and interdisciplinary communication for improved patient care is just as important.[41,39,80,50] Knowing that there will always be communication failure and being able to still provide good patient care and make decisions based on uncertainty whilst also trying to improve communication through the use of mutual systems, transmitting reliable up to date, well-structured information and the use of standardised operational terms is a difficult task to balance.[61,72,89,76,45,68,38,81,59,83,56] Information sharing and sharing of corporate knowledge is also vital. This could be done through better integration of operators, through liaison officers and the development of victim databases to allow for faster information gathering for relatives.[46,25,91,90,95,96,69] Public awareness of terrorism and its aftereffects should be improved through communication and training. [64,30,77]

Preparedness/Planning/Training

The most important lesson learnt within the preparedness/planning/training cluster was the need for regular drills and training in order to familiarise staff with the different processes and allow for a certain routine to develop.[12,35,40,42,54,59,67,77,88,89,28] It was hoped that through this, staff could fall back on a practised routine which would help calm the situation and reduce fear and anxiety in a real-life situation. Offering regular and different sorts of drills – small/large scale, interdisciplinary, regional and supra-regional ones - and trainings – triage, treatment, emergency medicine – can give overall reassurance to staff.[41-43,89,90,59,91] Collaboration with the military to teach combat medical care and combined trainings with police and the fire brigade can strengthen competencies and cooperation.[93,94,25,30,89,28] As experience was seen as the best preparation for further incidents, detailed evaluation of the problems and successes of previous attacks in a timely manner in order to allow for the adaptation and improvement of processes and emergency plans were seen as vital.[28,44,81,40,58,96,22,42,91,57,85] Local, regional, supra-regional, national and international concepts for streamlined strategy development and greater integration and standardisation were seen as a relevant factor in order to improve medical management of further attacks.[45,74,67,95,97,30,49,50] Within this area the provision and rehearsal of a detailed contingency plan for each and every hospital was seen as vital.[50,56,64,53,71,70,67,60,59,38,80,78,92,75,45,74] Hospitals should prepare meticulously during the latent phase of an attack. This needs good communication from the incident site to allow for an adequate surge in ICU and operating capacity, increase in staffing and emptying out of hospital.[42,51,55,49,89,54] Organised learning and training the public and subcategories such as medical students in terror awareness and first aid can lead to improved public engagement and empowerment.[67,28,30,77,38,94,95,25] Terror attacks often produce injury patterns unfamiliar to staff as blast injuries or gunshot wounds are not regular occurrences in most westernised countries. Providing focused training on dealing with these sort of injuries, dealing with paediatric casualties and using damage control concepts could help improve patient mortality in real life scenarios.[6,43,46,59,22,89,90,25] Whilst regular reviews and standardised ways of distributing lessons learnt as well as having stocked up supplies can help prepare for the next terror attack it was also noted that a certain degree of improvisation and uncertainty will always play a part and needs to be given room.[79,65,30,81,67,44]

Triage

Safe and effective triage was mentioned in 43 out of 68 articles. It was often stressed that the primary triage station should be placed within the save zone to avoid the loss of professional personnel especially during an ongoing terror attack.[42,39,93] Simple, quick, effective primary triage done by experienced staff and rapid transport to hospital based on triage priorities is one of the main pillars of effective prehospital treatment.[36,37,49,52,41,42,45,47,84,74,48,59,66,70,65,71,76,89,73] Using ATLS standards, national guidelines or concepts such as 3 ECHO can help streamline triage efforts.[94,37,96,59,41,56,72] The mantra "over-triage saves lives" should be used as a guideline during primary triage in order to not miss critically ill casualties.[45,48,49,54] A vital point of good patient care after terror attacks was diligence in the re-evaluation of patients' state along their treatment journey.[6,8,28,35,44,88,96,22,50,48,24] For this a secondary, tertiary or quaternary triage especially when arriving at different points of care such as the casualty collection point or clearing station, the hospital and the operating theatre or ICU are indispensable.[51,78,88,96] The need for constant re-evaluation was seen as important due to the possibility of quick changes in patients' states and hence changes in treatment necessities and adaptation of surge capacities and ICU/operating capacities.[55,85] Most articles agreed that the most experienced professionals, especially surgeons and anaesthetist, should be assigned to do primary triage, as their experience will allow for more timely and often more accurate decisions and avoid over or undertriage.[25,44,41,52,49] One article however pointed out that the most senior personnel would be needed to coordinate overall patient flow and should not be used for patient treatment.[59] Systematic planning, a good triage system with a directed patient flow and dedicated triage areas either within or even outside of the hospital are however definite factors that help structure a chaotic situation.[83,95,50,42,75] Being able to walk vs not being able to walk was seen as the most relevant triage factor however it was still mentioned that triage abilities should be regularly practised by staff and should be enhanced through teamwork.[25,95,42,72] Tertiary surveys to reduce the possibility of missed injuries should be performed within the following days once the situation has calmed down.[51] One interesting point was the idea to set up a triage hospital and direct patient flow from there to different hospitals depending on urgency and need for specialty treatment.[58]

Patient flow and distribution

Unidirectional patient flow was the most important lesson within the cluster of patient flow.[48,50,22,96,87,89,91,92] This concept was important at the incident site to allow for a quick evacuation of casualties out of an unsafe environment as well as during hospital treatment where the focus lay on quick redirection of casualties from the Emergency Department and triage area to avoid stacking up of patients and overload.[42,52,55,56,28,59,44,66,76,73,25,75] The focus was on quick assessment and movement to an area of more definite care on a one-way care pathway.[6,9,48,50,22,87,25,92,96] The nature of a terroristic attack includes an inadvertently unsafe environment and hence a big focus of prehospital care was a rapid scene clearance and the quickest possible movement of patients out of the danger zone and towards definite treatment within hospital.[52,73,59,55,91,56] Having a casualty clearing station and an effective casualty disposition framework with an enhanced triage process within the semi safe zone might help to achieve this goal.[94,95] Establishing a safe way for self-rescuer, who are often the majority of survivors, having a concept to swiftly deal with them and redirect them to satellite areas, or survivor reception centres are concepts that need to be in place quickly.[36,37,84,50,60,62-64] The biggest issue within this context, was the distribution of casualties to different hospitals with the closest hospital often being overwhelmed with patients and experiencing resource shortages.[40-42,47,66,70,69] Redirecting mildly injured patients to hospitals further away whilst stabilising critically ill patients at the closest hospitals as well as having a fast track route for patients with minor injuries might be a way forward.[36,60,52,71,59,74] Another approach that needs to be thought about by hospitals during the latent phase of an attack is the increase in ICU as well as general bed capacity by redistribution of current patients and even safe transfer of patients to different hospitals in preparation for the expected casualty influx.[51,39,44,83,95] This goes hand in hand with an estimation of needed ICU/operating capacity and possibilities of unlocking new areas of monitored beds such as the recovery room as impromptu ICU.[44,51] Once a hospital has reached capacity or has reached its limit in treatment options the possibility of secondary transfers to either a trauma centre or different hospital needs to be considered.[45,91,58,60] One last point a few articles mentioned was the fact that tracking patients, especially severely injured patients, throughout their treatment journey through hospital including save handovers was not an easy task and a concept for this should be developed.[44,92]

Cooperation and Multidisciplinary Approach

The aspect of cooperation and multidisciplinary approach was found all over the research. The complexity of the situation and of trauma patients, which are expected after terrorist attacks, and the need of a multidisciplinary approach in order to save as many lives as possible was a key statement.[91,48,53,64,67,71,83,22,89,87] Good teamwork and interdisciplinary working allows for better patient care especially under such difficult circumstances.[44,51,55,87,89] In the prehospital setting the cooperation, communication and interaction between the different emergency services is the single most important factor to allow for a safe, efficient and effective scene clearance.[6,53,71,22,83,91,93,94] One way to improve collaboration would be regular interdisciplinary trainings between police, fire service the emergency medical services and other emergency services on a local, regional and national level.[91,93-95] An interesting point that was mentioned a few times was the tactical cooperation between civilian rescue teams and the military. This included the possibility of training in combat casualty care, the cooperation between military and medical rescue teams during terrorist attacks and incorporation of military strategies in rescue planning.[15,89,30,92,95] Another focus was on the cooperation and communication between the incident site and hospital. Early information sharing, good communication between police, EMS and hospitals and the focus on a common goal were seen as important factors.[48,67,24,25,92] The idea of involving liaison officers who might have been trained in different disciplines or establishing police command centres in close proximity to hospitals in order to further improve cooperation and the sharing of corporate knowledge was mentioned.[93,50,95] Similarly a joint field command post and a combined activation of a common major incident plan can help focus attention and team work in order to provide safe and simultaneous search, rescue and treatment.[59,36,64,65] Multidisciplinary approaches to patient care within hospital were also a focus. This included multidisciplinary triage, regular multidisciplinary meetings, cooperation between the emergency department and other specialties, a multidisciplinary command structure and multi-professional networks.[51,55,56,95,80,74,83,59,91] Support from neighbouring regions, and cooperation of regional hospitals with trauma centres were also seen as important.[97,91] Whilst command and control was definitely seen as essential, it was also stressed that cooperation between rescue teams, flexibility and collaboration often helped to make things run smoother during the rescue operation whilst sharing information with the

police helped ease communication and information gathering for relatives and might help secure supply routes.[91,61,82,41,50]

Command

Establishing an incident command centre early on seems vital according to most articles.[37,38,50,83,92] Due to the danger of a second hit the main organisational headquarter should not be established at the incident site but rather be placed within the safe zone.[39,38] Due to the size and complexity of the rescue operation, a clear distinction in medical and organisational command helps to establish focus and efficiency.[51,65,48,67,81] The establishment of prompt and assertive leadership and the activation of advanced major incident management plans with already established command structures was seen as important factors in order to gain control over a very dynamic and critical situation.[64,76,56,42] To avoid improvisation the chain of command within the different hospitals should be already in place in order to only need activation.[64,76,41] The data disagrees on who should staff this chain of command. Whilst most articles suggest, that the most senior professionals should be working together with hospital admin to organise the hospital patient flow, a few articles suggest that the most senior professionals are needed on the ground for effective triage and patient treatment. However, all articles agree that experienced health care professionals play a major role within the coordination of the hospital response. [52,67,96,25,59,55,51,41,68,85,24,83] It is clear that a strict distinction between medical and organisational management is needed and each hospital should decide beforehand who will take up with role during a major incident and stick to this arrangement of strict command and control structures with designated hierarchies.[9,35,38,61,65,68,95,71,87,88,90,25] Robust, simple command structures based on knowledge and experience seems to be important in the prehospital as well as the hospital phase of a terror attack.[90,71,88,91] In combination with good collaboration and communication between the different EMS Services, flexibility, multidisciplinary management and clear role assignation it can improve overall outcome.[41,59,64,82,89,30] Whilst it is important to keep a general overview of which agency takes the lead one should also not forget that a terror attack always goes hand in hand with chaos and the establishment and communication of said command structures might cause issues, take time and be worsened with multiple sites of attack.[71,59,58,52,43]

Hence trying to always keep an overview seems to be more important than trying to control the details.[91]

Staffing

The surge capacity of staff is without a doubt the single most important factor for the successful medical and surgical management of terror victims within the hospital setting.[8,39,44,59-61,63,68,55,71,72,74,79]. Focusing on a quick and effective increase in staffing levels should be made a priority.[25,44,59-61] The increase in staff should also include areas such as the blood bank personnel, more specialised personnel such as psychiatry and ENT (Ears/Nose/Throat) and photography staff to allow for sufficient injury documentation.[96,62] Having backup personnel in reserve is however also important, considering that no one initially knows how long this state of emergency will continue.[22,83,86] Overcrowding of main areas such as the Emergency Department [69] can increase chaos and inefficiency hence an optimal utilisation of manpower and efficient staff allocation should be pursued.[46,56] Working in such an emotionally intense and physically straining environment can lead to quick and profound exhaustion of staff, hence sufficient breaks every 8-12h need to be considered and provided for in order to not compromise patient care.[28,44,51] With the news of a terroristic mass casualty event being broadcasted on the media, a lot of additional staff will automatically arrive at the hospital and offer help. It is therefore vital to keep a close list of who is who and has been deployed where.[44,51,56] This is not only important for keeping an overview but also to increase staff safety and not allow unknown personnel onto the premises without background checks.[36] During the latent phase hospitals should gather as much information as possible and establish a human resource pool.[51,50] Volunteers and freelancers can be difficult to manage but can be used as runners and to staff multiple triage areas.[36,71] Some articles mentioned that well trained and experienced staff are important in order to provide good patient care and successfully deal with a terror situation. [72,86] Hence increasing incentives for nurses, and training them in emergency medical skills and combat medicine might be one way to increase professionalism and a calm work environment in such a dramatic situation. [40,59,30] Having well trained prehospital personnel and having senior medical officers and pre-hospital physicians perform primary triage can save lives. [73,57,39] The idea of SWAT paramedics which can provide care under fire is successfully practised in

France, the USA and Israel but has not been adopted by many other countries yet.[93] When it comes to organisation, a clear description of relevant capabilities, using small teams and triage tags in order to attend more patients simultaneously and using helicopters to quickly mobilise staff and equipment can all help improve outcome.[52,58,59,65] Within hospital, forward employment of anaesthetist, a fixed doctor/nurse combination for each ED (emergency department) bed and assessment of casualties through anaesthetists, trauma and abdominal surgeons allows for effective treatment allocation and continuity of care.[55,49,50,44] Once the situation is under control a quick de-escalation and thorough psychological follow up for staff can help reduced the after effects of a terror attack. [35,8]

Medical Treatment and Type of Injury

Data from various articles suggest that 1/3 of all casualties from terror attacks are critically injured and 10% have life threatening injuries.[49,78] Other sources quote an average ISS Score of >15 for 5% of casualties, a score of >25 for 2% and an average ISS score of ICU admissions of 24.[50,51] What all articles do agree on however is, that terror attacks produce very unusual and specific injury patterns that many health care professionals are not extremely familiar with including blast injuries, blunt trauma, penetrating wounds and burns.[44,47,51,95] Blast injuries are often the main cause of immediate death [49] whilst the majority of survivors have only minor injuries, psychological effects or are "worried well" patients.[49,58] An effective way of dealing with these patients should be established early on to avoid overcrowding. For the majority of severely injured patient early aggressive resuscitation and rapid treatment predicts survival.[42,43,37] A mindset of damage control rather than definite individual care when it comes to treatment and surgical intervention is crucial especially in the early phases of the attack.[59,65,67,74,92,96] This is needed to increase surge capacity and avoid resource insufficiencies later on. [45,41,55] Using a combination of TCCC and ATLS Standards with a strict focus on aggressive resuscitation, haemorrhage control with the help of tourniquets, simple triage and rapid evacuation is the best way of achieving this aim at the site of attack.[96,22,84,89,94,80,30,25,58,52,42,37,45,59,43] Resuscitation efforts should only be started once staffing levels are sufficient and the extent of treatment on site should be directly linked to situational safety and type of attack. [59,94,43,46] Within hospitals the available surgical capacity needs to be increased and direct access to the operating

rooms needs to established.[87,42] Laboratory and radiological testing should be minimised and operations should be classified according to urgency and be restricted to damage control surgery only. [42,55,74,78,24] Early intervention is vital hence majorly injured patients should be treated in the closest hospital, even if this is not a level one trauma centre and only be transferred if necessary.[60] Personal knowledge and professional abilities have been shown to have a direct effect on patient outcome and hence training opportunities for trauma and terror related injury patterns as well as paediatric cases should be created.[61,89,25] In order to assess the medical care after a terror attack, critical mortality rates have been shown to be a good indicator. [42,55]

Equipment and Supplies

Within the equipment and supply cluster, the lessons learnt concentrated mainly on five different subheadings. Firstly, the importance of a quick and effective surge in supplies, secondly the need of functioning equipment and backup, thirdly safe and effective supply routes, fourthly preparation and last but not least ways to avoid overstretching resources. The need for a rapid surge in supply capacity was noted by most articles mentioning equipment.[44,59,73,64,90,95,94,92,25] The focus lay mainly on increasing the availability of basic equipment, in particular tourniquets and other haemorrhage control devices. [25,53,89,80] A few articles however mentioned the need to think about more advanced equipment such as CBRN tools and the importance of activating the blood banks to increase the available supply of blood products.[44,77,52] Having the awareness that the attack might continue for a lengthy amount of time, or factoring in a possible second hit at a distant location, is vital. These factors make resource allocation difficult and highlight the need to not deplete all resources directly but always keep some as backup for down the line.[72,85] In order to be able to have a well-functioning surge in supplies, reliable and well-organised supply chains are vital.[61] Early communication with vendors and cooperation with the police to allow a safe passage of supplies to the incident site increases efficiency.[50] Unconventional ideas such as using helicopters to transport supplies quickly might also be an option.[52] It is however not only the amount of supplies that is important but also its functionality. The awareness that equipment such as mobile phones or internet access might fail and having basic backup solutions such as radio communication or simple megaphones ready can make a huge difference in dealing with a terror situation. [35,50,59,73,82,64] Having

enough personal protective equipment to keep emergency medical services safe and having the capacity to protect all medical assets including supplies should also not be neglected.[42,59] Long term as well as on the spot preparation is crucial during a terror attack. Regular resource evaluation as well as having a major incident plan with detailed resource allocation which can be easily activated and leads to a quick regional resource mobilisation, allows for an effective surge capacity to develop and helps optimise utilisation.[74,25,41,58,46] Concepts such as first aid kits including tourniquets on busses, trams and the underground might improve first aid capacities and save lives.[64] Mobile mass casualty vehicles, which can be dispatched on demand can help relieve supply shortages at the incident site.[95,59] If hospitals are notified in advance about a mass influx of patients, the time should be used to prepare the emergency room to deal with multiple trauma patients.[44] Preparing disaster supply carts that are mobile and contain lifesaving equipment might be helpful.[51,83] There is a considerable risk of medical supply shortages and overstretching of resources during a terrorist attack. In order to avoid the main gate syndrome of close-by hospitals being overrun by patients only critically ill patients should be transferred to the closest hospitals whilst stable casualties should be evenly distributed between other hospitals.[25,45] A secondary wave of transport after primary stabilisation to more specialised centres in order to relieve pressures on the primary hospital should also always be considered.[45] Resource intensive services such as laboratory and radiological investigations should be kept to a bare minimum in line with the idea of combat care treatment. Reduced level of treatment per patient to avoid resource shortages, and the allocation of resources to life saving diagnoses should be a primarily applied concept in the prehospital as well as the hospital setting as long as the magnitude of the event has not been fully realised.[42,74,41,78]

Zoning and Scene Safety

Scene Safety and effective Zoning are paramount during a terror attack. The unpredictable nature of the situation and the risk of a continuous attack, a second hit or hospitals being seen as soft targets, make it nearly impossible to guarantee complete safety for rescue services or health care professionals.[56,79,25,94-96] Hence many articles stress the importance of a continuous re-evaluation of scene safety, awareness of its complexity, a robust management of uncertainties, an effective zoning

strategy and a focus on fast extradition and evacuation of casualties.[47,52,59,72,84,95] The safety of the emergency medical service and health care professionals are of top priority and often the extent of treatment can only be based on the situational safety.[94] Due to this, the primary triage area should be located outside of the hot-zone and conventional rescue teams as well as doctors should only be operating within the safe or semi-safe environment. [39,59,71,72,93,84] Another idea some articles favoured was the use of SWAT paramedics or a hazardous response team which includes health care professionals, who have been trained to deliver care under fire. [93,94] The risks of such a system with simultaneous search/rescue treatment, should however not be underestimated and the best compromise between terror control, safety of personnel, immediate care and fastest possible extradition needs to be found. [25,79,36,28] The tactical command post should always be placed within the safe zone, far away from the site of attack. This is important as the danger of a second hit should always be in the back of everyone's mind and the protection of trained personnel as well as the tactical leadership is paramount in this situation. [71,36,42,93] Full personal protective equipment as well as geographical knowledge of the first responders can help increase scene safety and speedy evacuation. [52,59,73] As the protection of hospital staff and patients needs to be taken serious, all hospitals should go into complete lockdown with security at all entrances and strip and search of all patients and health care professionals arriving at the different hospital sites.[35,54,83,50,75]

Psychological Support

When talking about psychological support there were two main foci of lessons learnt within the cluster. One was on the psychological support for victims, patients, survivors, and relatives and the other was on psychological support for the emergency service and hospital staff involved. For both sub-groups good and early psychological support has been identified as crucial. [38,42,49,74,57,67,85,95,97,96,89,50]   Having a designated treatment area for acute psychological issues [41] and a psychological support centre for relatives and only mildly or even uninjured victims has proven to be helpful in dealing with the situation.[22,62] Bereavement nurses should be accessible 24/7 for the first couple of days to help connect relatives to the right long term services and provide primary stabilisation.[97] Special focus should be given to acute psychological support first but should also include easy self-help techniques that can be practised at home in

the days and weeks to come. [97] As the psychological aspects of terror attacks continue far beyond the day of the attack, the importance of long term support including treatment and survivor groups and bereavement services was stressed.[25,43,97] Some articles mentioned that 1/3 of all victims develop PTSD (post traumatic stress disorder) and that especially high risk groups including health care professionals should be monitored closely.[97,25,64] The hazard and costs of developing PTSD for health care professionals should not be underestimated and robust psychological care especially targeting health care workers should be offered.[77,79,54] High role clarity amongst health care professionals and in depth, extensive debriefing are important factors in reducing PTSD and can help relieve stress. [59,86,97] Effective treatment of the psychological side-effects of terror attack reduces the long term costs and impact of said attack.[77,91] Formal as well as informal treatment such as debriefings and multi-professional team sessions can be seen as effective techniques in order to achieve this goal. [93,91] Outcome seems to be generally improved if everyone involved had early psychological support – patients before discharge and health care professionals before taking on normal responsibilities.[91,59]

Record Keeping

The cluster Record Keeping produced 16 lessons learnt and whilst the most commented one was the simple fact that record keeping was essential and should not be forgotten [53,56,65,71] there were a lot of quite specific lessons that should be dealt with in detail. One article focused on the need to strap patient documentation and identification directly to a patient in order to improve information transport from incident site to hospital. Considering that, for safety reasons, all patients should be stripped before hospital entry and the general risk of losing wallets and other identification methods being high, this seemed to be a useful hack to improve patient identification and also information about types of injuries.[42] According to Phillippe et al., better communication between incident site and hospitals can be achieved through good documentation, especially when it comes to patient information, injury patterns and triage results.[24] Different articles discussed the importance of early on site documentation of patients' and deceased's details, as the possibility of identification often gets much harder as soon as the victims have been moved.[97,64] The importance of this for family reunification and bereavement was particularly stressed. Using a standardised identification system, maybe even based on Interpol Disaster Victim

Identification Standards, and a regionally or nationally organised database was seen as one possibility to improve in this sector. [95,96,25,69] Another idea was the creation of a lead agency, which solely deals with patient identification during catastrophic events.[64] Most articles however agree, that victim identification poses major difficulties [24,89,92] whilst one article expressed the added difficulty of keeping track of who has already been triaged and who has not.[65] The difficulties of tracking patients continues in hospital. Dealing with a high influx of patients and having to track them through their hospital journey needs diligence and a solid IT infrastructure[92] whilst having photography staff present to document injuries might help improve outcome. [95] Another focus of some articles was record keeping and data collection of the rescue mission to allow for improvement during future events. [91,50,28]

Role Understanding

When it comes to role understanding, two general ideas were discussed in multiple articles. One was the physical aids needed to help clarify roles and make communication as well as team safety easier.[83,41,59] The second was the idea of designated roles, making the operational flow easier and reducing the risk of PTSD for rescue workers and hospital staff. [44,67,83,86] Clear identification methods are important during the medical management of terrorist attacks. This includes the site of attack as well as the hospital setting. As the surge in staff leads to large teams working together, it is vitally important to be able to identify staff and their roles without difficulties. Hence identification vests or tags should be available and worn by staff. [83,41,59] This does not only lead to more efficiency and better patient outcome but also increases the safety of staff by clearly identifying members of the team and keeping a track record of who present and in which role. Knowing your capabilities and dedicated roles help give security and confidence in extraordinary situations such as a terror attack and can help to improve outcome. [91,86] Having designated roles with clearly defined duties set out in the emergency plan, allows for a quick set up of command and control structures and a better organisation and faster capacity to act. [83,71,67,44] One particular study into the aftereffects of a terror attack highlights the fact that high clarity about personal role and duties reduces the likelihood of PTSD in rescue workers and hospital staff.[86] Another article focused on the importance of flexibility rather than rigid processes but

this needed flexibility would only be possible with clear role assignment especially within the command and control structure. [82]

Team Spirit

Even though team spirit was the least mentioned cluster in the articles, it was given much importance when mentioned. It was often quoted as a vitally important factor for all involved rescue services and staff to cope with the situation and to continue working despite the emotional strain and personal danger of the situation. Staff solidarity, professionalism and team spirit was noted as important factors for a successful operation.[91,88] The importance of mutual support was also noted. [94] This included mutual support between different rescue services as well as support between members of multidisciplinary teams. Supporting each other on a professional as well as a personal level in such an emotional situation was seen as important to improve outcome. Whilst one article focused on keeping up team spirit as responsibility of the command/team leader [57] others focused more on it being the responsibility of each and every one to keep team spirit up, form coalitions of mutual support and help each other through the tough experience of working in such a difficult situation. [82] One article interestingly spoke about the empowerment and engagement of the public during a terror attack.[30] It discussed that fact, that the public should be trained in basic life support and in general demeanour during a terror attack in order to be mentally better prepared and act rational during such a difficult situation.

Discussion/Interpretation Part II

Evaluation and Concept Integration

This systematic review aims to review the vast amount of literature on lessons learnt from terror attacks and is in this characteristic the first of its kind. It brings order to the multitude of defined lessons learnt and contributes to a better understanding of the consequences of terror attacks since 2001.

The data has shown quite clearly that, despite the difference in attacks, countries, social and political systems and casualties involved, many of the lessons learnt and

issues identified are similar. Treating casualties after a terrorist attack means working during exceptional circumstances. The high pressure, emotional, chaotic and dramatic environment under which health care professionals are expected to work in these situations bear multiple difficulties and seem to lead to very similar problems when it comes to effective execution no matter the specific circumstances. This allows the conclusion that many of the issues are of a general sort and not directly related to specific medical systems, political systems or countries. While this would allow for a standardised protocol/procedure that could be applied on a national as well as international level, it also shows that the issues faced are multi-facetted and broad and hence most likely difficult to address.

Figure 11 is a graph that shows how often a specific category was mentioned in articles released during each year. Interesting to note was the fact that time of release did not relate to content. Many articles written after the London attacks in 2005 formulated similar if not the same lessons learnt as articles written in 2017 about Utoya.[56,72] (Figure 11) This is a major point of concern as it indicates that despite the knowledge about the issues and the existence of already developed, excellent concepts [76,98,99], their successful implementation seems to be lacking.
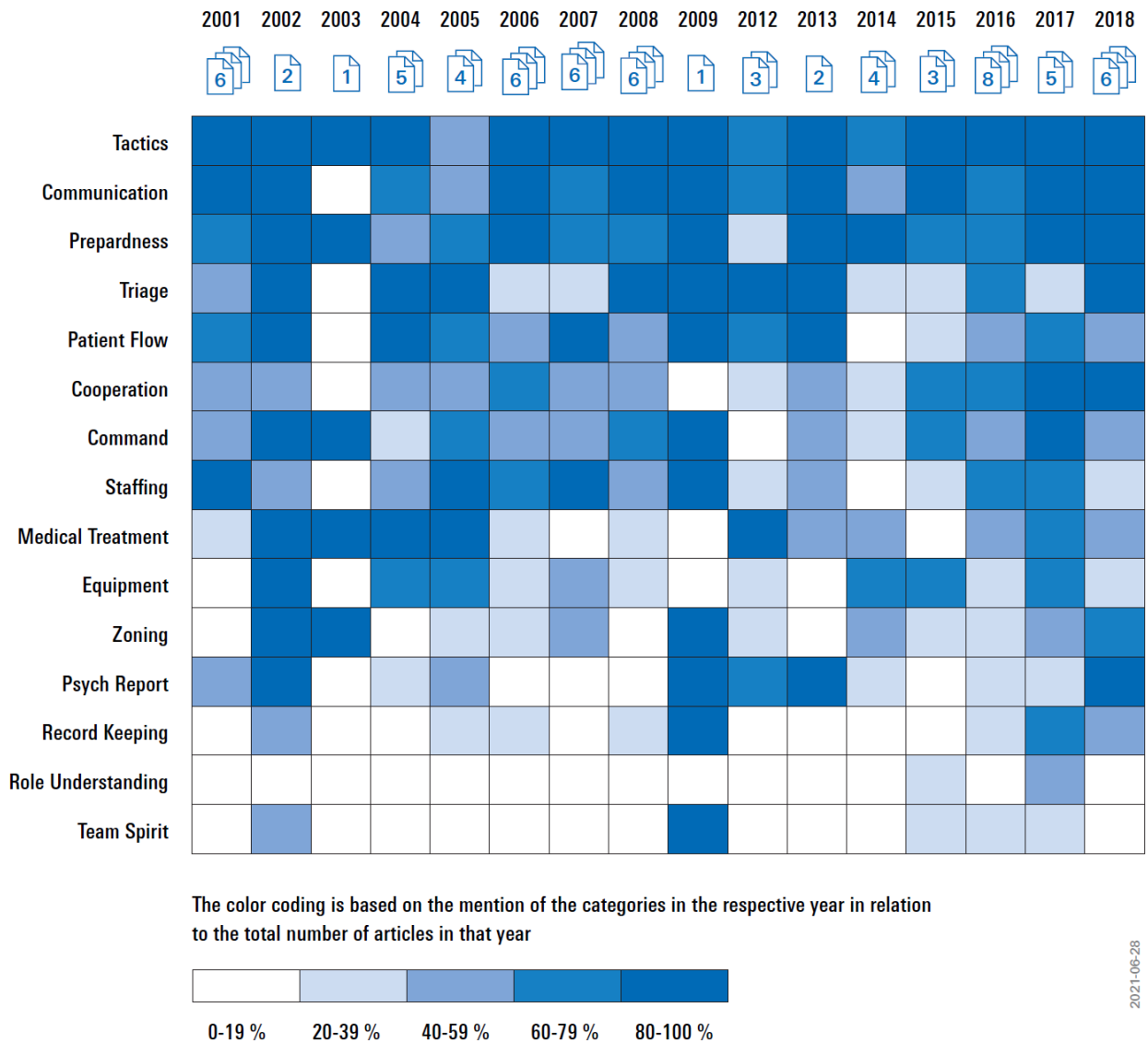
2001 2002 2003 2004 2005 2006 2007 2008 2009 2012 2013 2014 2015 2016 2017 2018

6 2 1 5 4 6 6 6 1 3 2 4 3 8 5 6

Tactics
Communication
Prepardness
Triage
Patient Flow
Cooperation
Command
Staffing
Medical Treatment
Equipment
Zoning
Psych Report
Record Keeping
Role Understanding
Team Spirit

The color coding is based on the mention of the categories in the respective year in relation to the total number of articles in that year

0-19 %   20-39 %   40-59 %   60-79 %   80-100 %

2021-06-28

Figure 11 Frequency of mentioning the categories per year over the entire study period

Tactical Combat Casualty Care (TCCC) is one of these well – developed concepts and started in 1996 as a special operation medical research program. Since then it has become an integral part of the US Army's trauma care and is regularly reviewed by the Committee on TCCC. [98] Many of the lessons learnt listed in this systematic literature review are an integral part of these guidelines and are addressed with concrete options for action. Tactical Evacuation Care for example, an integral part of TCCC, deals with the management of casualties when timely evacuation from a danger zone is necessary and addresses many of the lessons learnt such as early evacuation, zoning

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and scene safety assessment.[100] Moreover, the lack of knowledge on how to deal with injuries caused by firearms or explosive devices, which was mentioned in many articles, could be remedied by a consistent integration of the TCCC guidelines into the training and drills of emergency service personnel.

The Medical Disaster Preparedness Concept "THREAT" is another well-known concept, that was published after the Hartford Consensus in 2013 and deals with the management of mass shootings and intentional mass casualty events.[76] The defined THREAT concept components were:

T: Threat suppression

H: Haemorrhage Control

RE: Rapid Extraction to safety

A: Assessment by medical providers

T: Transport to definitive care

Within each component, multiple issues were identified as lessons learnt and measures to address these were discussed. These lessons learnt were included in our literature review and correlated with many issues noted in other articles. Consistent implementation of these points in training and practice would be an important step towards improving preparation for terror attacks.

The 3 ECHO Concept (Enter, Evaluate, Evacuate) was developed in order to optimize the management of mass shooting events and is a good example of the successful implementation of an inter-professional concept.[99] 3 ECHO was based on defining existing deficits and formulating specific remedies for these deficits. Many of these deficits correspond to those that were found in the presented systematic review. The introduction of the concept in training and practice has led to successful management of a mass shooting event in Minneapolis, Minnesota, USA in 2012.[99] This, once again, shows the importance of translating lessons learnt into concrete concepts, integrating them into training and practicing them regularly in inter-professional drills. A similar concept to 3 ECHO is the Joint Emergency Services Interoperability Principles (JESIP)

project.[101] It is based on the same principles of inter-professional cooperation and teamwork as 3 ECHO.[101] It is the British standard for the inter-professional cooperation of emergency services in major emergencies or disasters. Through simple instructions and a clear concept, both the aspect of planning and preparation as well as the concrete management of operations are taken care of. [101]

Applicability and Comparison

In interpreting the lessons learnt in this systematic review, the question arises whether they are specific to terrorist attacks. While this literature review deals exclusively with lessons learnt from terrorist attacks, other publications, systematically addressed the management of non-terrorist mass shootings and disasters. One of these publications is Turner et al. who reported the results of a systematic review of the literature on prehospital management of mass casualty civilian shootings. [31] The authors identified the "need for integration of tactical emergency medical services, improved cross-service education on effective haemorrhage control, the need for early and effective triage by senior clinicians and the need for regular mass casualty incident simulations"[(10)31] as key themes. These themes correspond congruently with the lessons learnt from terrorist attacks that were found and presented in this systematic review.

Another research by Hugelius et al. concentrated on identifying problems when managing mass casualty incidents or disaster situations. The authors identified five different challenges. [102] These were "to identify the situation and deal with uncertainty", "to balance the mismatch between contingency plan and reality", "to establish functional crisis organisation", "to adapt the medical response to actual and overall situation" and "to ensure a resilient response".[(11) 102] Within the 20 included articles in this study 5 dealt with terror and mass shootings including the attacks in Paris and

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[10] Turner CDA, Lockey DJ, Rehn M. Pre-hospital management of mass casualty civilian shootings: a systematic literature review. *Crit Care*. 2016;20(1):362. doi:10.1186/s13054-016-1543-7
[11] Hugelius K, Becker J, Adolfsson A. Five Challenges When Managing Mass Casualty or Disaster Situations: A Review Study. *Int J Environ Res Public Health*. 2020;17(9). doi:10.3390/ijerph17093068 p5

Utoya. Although only 25% of the included articles dealt with terrorist attacks, the lessons learnt were again remarkably similar to the lessons learnt from this review and might be an indication that many of them might be widely applicable.

Challen et al. published the results from a scoping review in 2012.[103] The authors stated that "although a large body of literature exists, its validity and generalisability is unclear." [103] They also insisted that the type and structure of evidence that would be most helpful for emergency planning and policy makers still needs to be identified. With the here presented systematic review of the literature a big step towards an easy to understand, clear overview of issues that need to be addressed has been made and should be seen as a step in the right direction as it provides a structured summary of evidence that could be used as a starting point for policy makers.

In conclusion this systematic review is the first of its kind to review the vast amount of literature dealing with lessons learnt from terroristic attacks. It thus contributes to a better understanding of the consequences of the terror attacks since 2001. It also brings order and overview to the multitude of defined lessons learnt and important findings result from it. The first thing that stands out is that the lessons learnt follow a certain pattern. This pattern seems to be independent of the country, the medical system and the type of terror attack and hence allows for great international applicability.[104] Likewise, this pattern repeats itself over the entire time frame considered in the systematic review. It can be assumed that in many cases it is therefore more a matter of lessons identified rather than lessons learnt. This seems to be the case despite the development of excellent concepts that were implemented to help deal with patient care under dangerous circumstances. If this is due to the lack of evaluation, lack of planning, lack of implementation or lack of success is beyond the scope of this study. It is however clear that there still seems to be room for improvement, further research and wider application as well as advancement of concepts in order to translate the valuable lessons learnt from the terrorist attacks of the last 20 years sufficiently into action. This will help achieve the goal of saving as many victims of terrorist attacks as possible and to protect the rescue forces from harm as best as possible.

Limitations

This systematic review has several limitations. A Prospero Registration of the study has been attempted but was denied due to the character of the work as a systematic review. Due to the vast amount of information, only PubMed was used as a source. From the authors' point of view, this is a formal disadvantage, but it does not change the significance of the study as in contrast to the question of therapy effectiveness or the comparison of two forms of therapy, the aim here is to systematically present lessons learnt. In order to get even more information, the data search could have been extended to other databases (i.e. Cochrane Library, Web of science) and the grey literature. Given the number of included articles however, it is questionable whether this would have significantly changed the central message of the study. It is even possible that this would have made a systematic presentation and discussion even more difficult. The data interpretation has been focused on overall lessons learnt. It could be further divided into prehospital and hospital relevance to allow for a more focused approach. CBRN attacks have been excluded from the research. The reason for that was that many special aspects have to be taken into account in these attacks. Nevertheless, CBRN attacks are an important topic, which would need further exploration in the future. Only a adapted version of the PRISMA guidelines could be used as guidelines that fully fit the research criteria do not exist.[105] The restriction to OECD countries certainly causes a special view on the lessons learnt and is thus also a source of bias. However, the aim was to look specifically at countries where terror attacks are a rather rare event and rescue forces and hospitals are often unfamiliar with managing these challenges. Special injury patterns associated with terror attacks were not considered. This reduces the overall spectrum of included articles, but from the authors' point of view, a consideration of these would have exceeded the scope of this review.

Conclusion

This paper set out to compile a comprehensive list of lessons learnt about the medical and surgical management of patients after terror attacks. It did this by reviewing the academic literature from 2001 to 2018 and extracting all lessons learnt from the 68 included articles. 616 lessons learnt were extracted, categorised and discussed. The data has shown that despite differences in political structures, medical services and type of attack most of the problems identified and lessons learnt are comparable if not similar. This might suggest that national or even international cooperation might be a possibility in the future. It was also noted that many of the lessons learnt were of general nature and easy to understand and comprehend. However, as the data shows, many of the lessons learnt were constantly reported over time. This might suggest the conclusion that so far it has been partly a matter of lessons identified rather than lessons learnt. Despite the fact that multiple concepts have been developed to improve the management of mass casualty incidents including terror attacks, it still seems that there is a lot of work that needs to be done to further improve the management of terror attacks and hence outcome and survival rates. Concepts such as JESIP and THREAT which help structure the approaches to disaster management, need to be more widely implemented. Learning from each other and using unifying concepts and approaches might help improve further. This paper intended to create an academic basis on which such concepts could, in future, be developed and ultimately help save the lives of patients as well as emergency personnel.

Zusammenfassung

Diese Arbeit erstellt eine ausführliche Liste von lessons learnt über die medizinische Behandlung von Terroropfern. Zu diesem Zweck wurde eine systematische Literaturrecherche der Literatur von 2001 bis 2018 durchgeführt. Es wurden 68 Artikel in die Recherche inkludiert und 616 lessons learnt extrahiert. Die Daten zeigen, dass trotz Unterschiede in politischen Strukturen, Terrorattacken und medizinischen Systemen, viele lessons learnt ähnlich oder sogar identisch sind. Das eröffnet die Möglichkeit zu nationalen oder sogar internationalen Kooperationen. Des Weiteren zeigten sich viele lessons über den Recherchezeitraum konstant, was die Vermutung nahelegt, dass es sich eher um identifizierte Problematiken und weniger um gelernte Lektionen handelt. Obwohl in den letzten Jahren bereits mehrere gute Behandlungskonzepte für komplexe Einsatzlagen mit Massenanfall von Verletzten, wie zum Beispiel JESIP oder THREAT, eingeführt wurden, besteht immer noch Verbesserungsbedarf. Diese Arbeit versucht eine akademische Grundlage zu schaffen um diese Verbesserung voranzutreiben und ultimativ zu einer sichereren und effizienteren Einsatzbewältigung bei Terroreinsätzen zu führen.

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Appendix

I List of abbreviations

ABCD	Airway, Breathing, Circulation, Disability
ATLS	Advanced Trauma Life Support
C-ABC	critical bleeding, Airway, Breathing, Circulation
CBRN warfare	chemical, biological, radiological and nuclear warfare
DISAST – CIR	Disastrous Incidents Systematic Analysis Through Components, Interactions, Results
ED	Emergency Department
EMS	Emergency Medical Services
ENT	Ears + Nose and Throat
ETA	Euskadi Ta Askatasuna
EU	European Union
HEMS	Helicopter Emergency Medical Services
ICU	Intensive Care Unit
IRA	Irish Republican Army
ISIL	Islamic State of Iraq and the Levant
ISS	Injury Severity Score
JESIP	Joint Emergency Services Interoperability Principle
METHANE	major incident/ exact location / type/ hazard/ access/ number of casualties/ emergency services needed
NATO	North Atlantic Treaty Organisation
OECD	Organisation for Economic Cooperation and Development
PKK	Kurdish Worker Party
PTSD	Post Traumatic Stress Disorder
SARS COV 2	severe acute respiratory syndrome coronavirus type 2
TCCC	Tactical Combat Casualty Care
TEMS	Tactical Emergency Medical Services
THREAT	Threat suppression, Haemorrhage Control, Rapid extrication to safety, Assessment by medical providers and transport to definite care
3 ECHO	Enter, Evaluate, Evacuate
SWAT	Special Weapons and Tactics
UK	United Kingdom
US/USA	United States of America

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