Disaster Medicine;
From Preparedness to Follow up

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Disaster Medicine; From Preparedness to Follow up
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(met een samenvatting in het Nederlands)

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To Isabella

Contents

Chapter 1

Introduction

Introduction

A sudden, unexpected surge of casualties due to a disaster or major incident poses a huge challenge to provide optimal care. By definition, the requirements of such cases exceed the standard care facilities of hospitals in qualitative or quantitative respects and interfere with the care of regular patients. The terminology most generally used identifies two levels; 1) *Major Incident* (in more extensive form *Mass Casualty Incident or MCI*): a situation where available resources could be sufficient in relation to the immediate need of medical care, but where measurements such as adjustment of the working methods and/or mobilization and redistribution of resources is necessary to maintain the level of care; and 2) *disaster*: a similar situation but with such heavy load of casualties that the level of care cannot be maintained despite the above mentioned measures.[1, 2]

The medical management of an unexpected large number of casualties does not simply involve treating these like regular trauma care in up-scaled proportions. It requires a paradigm change in concepts, approaches and mindset.[1, 3] In regular management of trauma, virtually all injured patients are brought to hospitals where extensive time and resources are applied to the evaluation and care of every individual. In mass casualty incidents however, large numbers of casualties that are not critically injured threaten to delay the recognition and care of a small majority with urgent and salvable life-threatening injuries at immediate risk of death.[4, 5] The goal of treatment in this setting must change from the greatest good for each individual to the greatest good for the greatest number. The population as a whole, rather than the individual, must be the focus of management.[4, 5] An important instrument to reach this goal is triage. *Triage* is the prioritizing of patients according to injury severity and need for immediate care and is used to sort out the minority of casualties that are critically injured. Rapid and accurate triage, adapted to the situation, is essential to minimize mortality. Undertriage can lead to preventable deaths as life-threatening conditions are not recognized and treatment is delayed. In contrast to regular care where it merely generates costs, overtriage in mass casualty situations can also lead to excess mortality by withholding immediate care from other critically injured patients.[5, 6] The goal during major incidents and disaster is to deliver *minimal acceptable care;* only the briefest stabilizing care in the shortest possible time as long as the incident is still evolving and casualty influx is continuing. Once the influx has stopped, the patient load is well defined and hospital resources are fully mobilized, priorities for definite care can be made and provided.[2]

Mass casualties and disasters are a relatively rare occurrence for individual health care workers and therefore the mindset for disaster medicine and e.g. adapted methods of triage are not part of daily medical practice. Preparation and training for this entirely different approach of evaluation and care is thus essential to cope with the challenge of optimal allocation of resources and care to minimize excess morbidity and mortality.[1, 3] Although disasters and major incidents occur suddenly and are unpredictable in their nature, time and place, they can be anticipated.[7, 8] Despite the fact that they differ in type, size and etiology, there are certain medical and organizational problems that are common to all major incidents.[4] Discrepancy between immediately available resources and the number of victims, inadequate distribution of these resources, lack of overview, and especially effective and reliable information (exchange) are frequently encountered barriers to an effective response.[4, 9-12]

In order to meet the increasing demand of being prepared for disasters, a centrally located, permanent facility to provide structured, prepared relief in such situations in The Netherlands was developed. The Major Incident Hospital was formed during the building of the University Medical Centre Utrecht, when a separate nuclear-proof facility was built in the basement. Later on, this was rebuilt into an emergency hospital in order to provide infrastructure for the care of large numbers of military casualties. The growing demand for civilian major incident relief preparedness resulted in its goals being extended beyond the military to civilian disaster casualties. The outbreak of the Gulf War in 1990 accelerated its operational status.
One of the deployments of the MIH studied in this thesis was for repatriated victims of the 2004 tsunami.

This thesis focuses on preparedness (Chapters 2-4), care (Chapters 3, 5, 6,7) and follow-up (Chapters 5-8) for victims of disasters and major incidents, and explores new opportunities to improve disaster relief using the Internet as a supportive tool (Chapters 4, 7, 8).

Chapter 2 describes the development of the Major Incident Hospital (MIH) as a permanent, reserved facility to provide immediate emergency care for multiple casualties of a disaster or incident. It discusses the infrastructure, organisation, support systems and systematic working methods and how they facilitate triage and care for multiple, simultaneous patients under exceptional circumstances. The method of instant activation and the five scenario's for deployment are described.

Research and evaluation of past incidents provide knowledge for preparedness and response to future unknown incidents, which proved essential for further improvements.[5] In **Chapter 3** the implemented organisation, as well as the use of the MIH, are evaluated to identify strengths and weaknesses. All 34 deployments since the foundation in 1991 have been analysed according to the Protocol for Reports from Major Accidents and Disasters[13], along with the 5 scenario's for activation.

To overcome the problems of lack of victim overview and information sharing among disaster relief partners, as typically experienced in major incident relief [9, 10, 14, 15], an online Victim Tracking and Tracing System (ViTTS) was developed. This system and the testing thereof are described in **Chapter 4**.

One of the deployments of the MIH was for repatriated Dutch victims of the 2004 tsunami.
On December 26, 2004 an undersea earthquake in the Indian Ocean resulted in an enormous tsunami. This 'South Asian Tsunami' devastated the coasts of most landmasses bordering the Indian Ocean, killing over 230,000 people in fourteen countries, and inundating coastal communities with waves up to 30 meters (98 ft) high. It was one of the deadliest natural disasters in recorded history.

In the aftermath of the disaster numerous victims developed severe wound infections.[16-19] The initial stream of victims in the affected area was enormous. It had to be managed under extraordinary circumstances, often with too few staff, surgical equipment, and antibiotics. This posed huge challenges to the treatment of wounds. Wounds were often empirically treated with antibiotics, without the support of culture results. The medical literature, Internet and lay press carried reports of patients being at risk of deadly fungal infections and infections caused by waterborne and highly resistant pathogens. In most cases, the early reports concerned only one or a few repatriated travellers.[20,21]
Thirty-six Dutch citizens died as a direct result of the tsunami. Of the 500 Dutch citizens that were in the affected area, 23 wounded victims were repatriated to the MIH on New Year's Eve 2004-2005. Most patients had been treated or admitted to hospitals in Thailand. The Netherlands follows a strict quarantine policy ('search and destroy')[22] for all foreign patients in order to rule out methicillin-resistant *Staphylococcus Aureus* (MRSA) and other multi-resistant bacteria to prevent transmission to other patients and health care workers. Consequently, the entire group had to be treated in quarantine.

Chapter 5 analyses the wound infections, the culture results, and the resistance patterns in that group of wounded tsunami victims that were repatriated to the MIH. Cultured micro-organisms and resistance patterns were evaluated in relation to clinical picture, current as well as previous (antibiotic) treatment and coexisting conditions.

In addition to physical injury and loss of loved ones or personal belongings, exposure to a disaster can have a high impact on mental health. While immediate effects are well recognized and studied, long-term studies on effects on both physical and mental health as well as on quality of life are scarce. Less is known about disaster-exposed tourists repatriated to stable societies and about the differential effect of being wounded. In **Chapter 6** the group of wounded repatriated victims to the Major incident Hospital was included in a prospective 5-year follow-up study on physical and psychological impact of the tsunami and quality of life.

From the group of repatriated tsunami victims in the MIH came a spontaneous call for a communication platform. Many had lost track of each other during the disaster, had been befriended in the crisis, shared despair, were physically injured, and had been fearful of death or lost loved ones. The tsunami had confronted them with enormous devastation and many had seen countless dead bodies.
This triggered the set up of a web service to enable contact among peers, and facilitate community building among survivors. Within three weeks after the disaster a website with 4 features was launched: 1) information, 2) a forum aimed at community building and peer support, 3) self-assessment tools coupled with a research survey and 4) e-Consult. **Chapter 7** describes the set-up and use of this service and discusses the opportunities and difficulties it presented.

Through the Dutch portal of the site, 144 of the total of 500 Dutch tsunami victims participated in the online survey. **Chapter 8** describes the results of this survey. In four time periods over four years, the general level of psychological and physical distress, the degree of intrusions and avoidance reactions and the presence of depressive symptoms were analysed. Furthermore, the differential effect of physical injury, duration of danger to life and loss of loved ones on these function domains was studied.

The studies in this thesis are summarised and discussed in **Chapter 9.**

Chapter 10 presents a summary in Dutch**.**

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Chapter 2

Major Incident Hospital: Development of a permanent facility for management of incident casualties

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Eur J Trauma Emerg Surg 2009;35: 203-11

Abstract

Introduction

Preparation is essential to cope with the challenge of providing optimal care when there is a sudden, unexpected surge of casualties due to a disaster or major incident. By definition, the requirements of such cases exceed the standard care facilities of hospitals in qualitative or quantitative respects and interfere with the care of regular patients. To meet the growing demands to be prepared for disasters, a permanent facility to provide structured, prepared relief in such situations was developed.

Methods

A permanent but reserved Major Incident Hospital (MIH) has been developed through cooperation between a large academic medical institution, a trauma centre, a military hospital, and the National Poison Information Centre (NVIC). The infrastructure, organisation, support systems, training and systematic working methods of the MIH are designed to create order in a chaotic, unexpected situation and to optimize care and logistics in any possible scenario. Focus points are: patient flow and triage, registration, communication, evaluation and training. Research and literature are used to identify characteristic pitfalls due to the chaos associated with and the unexpected nature of disasters, and to adapt our organization.

Results

At the MIH, the exceptional has become the core business, and preparation for disaster and large-scale emergency care is a daily occupation. An Emergency Response Protocol enables admittance to the normally dormant hospital of up to 100 (in exceptional cases even 300) patients after a start-up time of only 15 minutes. The Patient Barcode Registration System (PBR) with EAN codes guarantees quick and adequate registration of patient data to order to facilitate good medical coordination and follow up during a major incident.

Discussion

The fact that the hospital is strictly reserved for this type of care guarantees availability and minimizes impact on normal care. When it is not being used during a major incident, there is time to address training and research. Collaboration with the NVIC and infrastructural adjustments enables not only care for patients with physical trauma, but also provision of centralized care of patients under quarantine conditions for e.g. MRSA, SARS, smallpox, chemical or biological hazards. Triage plays an important role in medical disaster management and is therefore key to organization and infrastructure. Caps facilitate role distribution and recognizibility. The PBR resulted in more accurate registration and real-

time availability of patient and group information. Infrastructure and a plan is not enough; training, research and evaluation are necessary to continuously work on disaster preparedness.

Conclusion

The Major Incident Hospital in Utrecht (the Netherlands) is a globally unique facility that can provide immediate emergency care for multiple casualties under exceptional circumstances. Resulting from the cooperation between a large academic medical institution, a trauma centre, a military hospital, and the NVIC, the MIH offers not only a good and complete infrastructure, but also the expertise required to provide large-scale emergency care during disasters and major incidents.

Introduction: goal and mission

The unexpected surge of casualties from a disaster or major incident poses a challenge to medical institutions. By definition, requirements exceed the standard care facilities of hospitals in qualitative or quantitative respects and interfere with the care for regular patients. Preparation and training are the key to success in delivering an adequate response.[1,2]

The growing demand for military as well as civilian preparedness for major incident relief stimulated us to develop a facility to provide acute, short-term relief during accidents and disasters that exceed the capacity of regular hospitals in terms of quality or quantity. This should be permanent, up to date and readily available.

Potential scenarios for which relief should be provided can be divided into five major groups:

- War or threat of war, crisis or conflict management in which large numbers of casualties need care.
- Accidents abroad involving Dutch citizens, civilian or military, who are in need of repatriation and medical care.
- Specific incidents, attacks or large-scale accidents in the Netherlands that exceed capacities of regular care facilities.
- International medical assistance from the Dutch government concerning the treatment of foreign victims.
- Quarantine care for patients with special infectious and highly contagious diseases such as SARS.

In this paper we describe the development of The Major Incident Hospital (MIH) in Utrecht (Netherlands), a globally unique facility that can now provide immediate emergency care for multiple casualties under exceptional circumstances.

Methods

The MIH was initiated during the building of the University Medical Centre Utrecht (UMCU), when a separate nuclear-proof facility was built in the basement. Later on, this was rebuilt into an emergency hospital in order to provide infrastructure for the care of large numbers of military casualties. The growing demand for civilian major incident relief preparedness resulted in its goals being extended beyond the military to civil disaster casualties. The outbreak of the Gulf War in 1990 accelerated its operational status.

MIH is the result of cooperation between the Ministy of Defence's Central Military hospital (CMH), the UMCU and the National Poison Information Centre

(NVIC). Cooperation between a large academic medical institution, a trauma centre, the military hospital, and the National Poison Information Centre, offers not only a sufficient and up-to-date infrastructure but also provides a broad expertise, which is essential in order to cope with large-scale emergency care during disasters and major incidents (*Figure 1*).

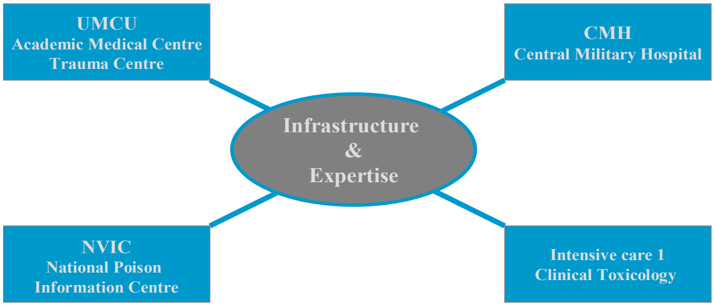

Figure 1. Contributors to infrastructure and expertise of the MIH.

To ensure its availability and to make sure that preparation for disaster and large-scale emergency care remains a daily occupation, the MIH is a reserved hospital.

In order to be able to work under many different circumstances, different aspects of the relief process are focused on in advance, irrespective of the future cause of the disaster/multiple casualties. The infrastructure, organisation, support systems, training and systematic working methods of the MIH are designed to create order in a chaotic, unexpected situation and optimize care and logistics in any possible scenario. Infrastructure is explicitly adapted to triage and patient flow through different echelons of care. We developed an emergency protocol to direct staffing, start-up and relief itself. The personnel involved are either fulltime workers, are directly available on demand, or are part of a pool of personnel that can be drawn from the UMCU or the MIH.

To ensure adequate registration and up to date information on patient (group) characteristics, we developed a bar code system. Its use has been extended over the years. Communication and security are accounted for by protocols to apply when informing families and the press, a continuously reserved capacity on (for example) the phone network and the ability to restrict the access of unauthorized personnel to the area of the MIH.

Evaluation, research and training are incorporated in the daily tasks of our full-time staff. They train other involved staff and volunteers regularly.

Results

Infrastructure

The MIH is a dormant hospital located in an 8.000 m2 underground nuclear proof facility under the UMCU. The hospital consists of a triage and immediate treatment area (35 beds), intensive care (12), medium-care (30) and two low-care departments (200). All of the departments can be extended to reach a total capacity of 300 patients. There are four quarantine boxes, three operation rooms with recovery, and a radiology department for conventional and ultrasound radiology (*see Figure 2*). It has its own energy, informatics and medical gas supplies. Air conditioning is performed through a separate closed system with special air filters, enabling centralized quarantine care for patients with contagious conditions as SARS, smallpox, chemical or biological agents. A widely available network with terminals and hand held devices supports the information and communication traffic (e.g. the barcode system discussed later in this manuscript).

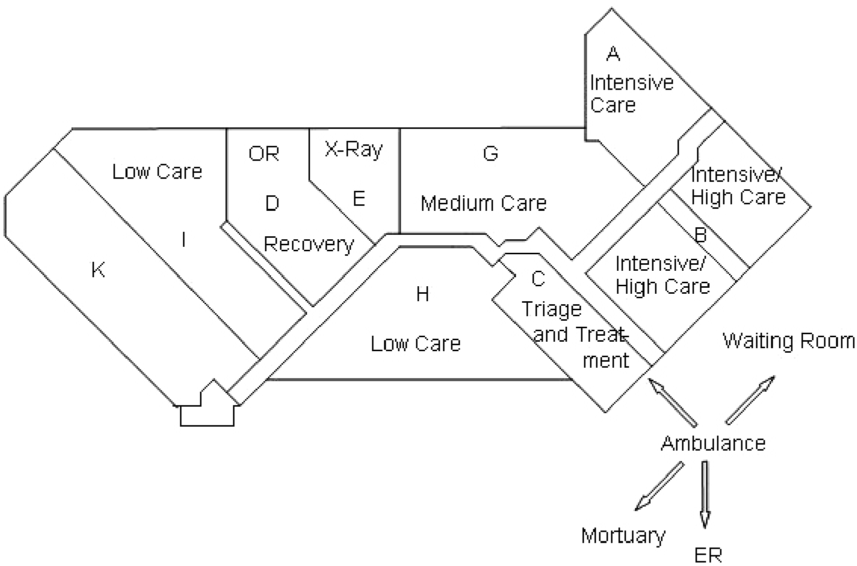

Figure 2. Map of the Major Incident Hospital

Emergency Response Protocol (ERP) and the teams

Since its foundation in 1992 the MIH has admitted over 500 patients, in groups of 5-150 patients at a time (*see Table 1*). It can be activated through an ERP (see below). The ERP enables the admittance of up to 100 patients after a start-up time of only 30 minutes. In exceptional circumstances this can be expanded to 300 patients.

Table 1. Overview of MIH use.

Year	Number of admitted casualties	Incident characteristics (location of incident, if abroad)
1991	9	Methylbromide intoxication
1991	9	Carbonmonoxide intoxication
1992	10	Carbonmonoxide intoxication
1992	5	Exposure to nitrous damps
1992	28	Evacuation of a hospital in a war setting (Bosnia Herzegovina)
1992	13	Plane crash (Faro, Portugal)
1993	43	Bus accident (Lyon, France)
1993	5	Evacuation of a hospital in a war setting (Bosnia Herzegovina)
1994	4	Busaccident (Regensburg, Germany)
1995	143	Evacuation of a flooded Hospital
1995	7	Benzylbromide exposure
1996	29	Bus accident (Winterberg, Germany)
1996	12	Cannabis intoxication
1996	6	Aluminium intoxication (Curacao)
1996	11	Bus accident (Antalya, Turkey)
1996	17	Carbonmonoxide intoxication
1996	10	Bus accident (Thionville, France)
1997	6	Military accident (Novi Travnik, Bosnia Herzegovina)
1997	13	Bus accident (Syria)
1998	20	Bus accident (Metz, France)
1999	5	Repatriation of fugitives (Kosovo)
1999	12	Earthquake (Turkey)
2000	9	Military accident (Germany)
2002	25	Busaccident (Metz, France)
2002	22(*)	Busaccident (Manching, Germany)
2005	23	Tsunami (Asia)
2007	6	Collapse of a crane
Total	**511**	

(*) concerns two separate groups

After a major incident the decision regarding whether or not to open the MIH has to be made. In a case of a national emergency, the MIH will be opened at the discression of the surgeon on call, the board of the UMCU and the Command

Team of the MIH. In the case of an international incident, this decision will often be in cooperation with the Ministry of Defence or Health.
When the decision to open the MIH has been made, the Commanding Team determines the space and personnel required as well as the need for logistic support. An automated warning system is activated by the Command Team. This system was developed under our directions by the national telephone company (KPN). When activated, it starts to call phone numbers of a predefined list with an average rate of 100 (mobile) phone numbers in ten minutes. This predefined list contains personnel from every specialty and support facility e.g. fire department, security, kitchen, microbiology, surgery etc. A computerized system invites the called person to reply by pressing a specific number defining whether or not they are available and the time they will need to reach the MIH. It is possible to continuously monitor all personnel en route, and to display this information.
The personnel can be classified into three levels of involvement. First, personnel that solely work in the MIH: 3 fte are responsible for logistics and infrastructure; 1 fte care manager is involved development of the procedures, protocols and training; 0,6 fte is reserved for administrative support and a 0,5 fte ICU nurse is available to train military personnel all year round.
Second, 17 fte are employed by the MIH and, next to frequent training, these personnel also perform regular care tasks in the UMCU and CMH when the MIH is dormant. They are readily available when the MIH opens up. Also, there is a separate dedicated management team of 4 fte.
Third, there is a pool of dedicated and specially trained doctors, nurses and support staff from all departments in the University Hospital that can be retrieved when the MIH opens up.
If necessary, a Coordination Team consisting of an ER nurse, an ICU nurse and the Commanding Officer of the UMCU Fire Department covers the time from the first alarm until the first medic or nurse of the Command Team has arrived. They can engage the MIH and coordinate (the preparations for) the initial patient relief. This is supported by plasticized checklists with tasks and responsibilities stated for every discipline , which are handed out to the officers.
In every department, a co-ordinating physician wearing a green cap and a co-ordinating nurse, wearing red cap are present along with nurses, an administrative cooperator, volunteers from the Red Cross for psychological support and volunteers of the UMC Utrecht for patient transport. These caps facilitate swift role identification irrespective of personal acquaintance and emphasises role distribution among personnel that do not work together on a daily basis (*Figure 3*).

Figure 3. Caps facilitate recognition of the coordinator and emphasize the distribution of roles.

Patient Barcode Registration System (PBR)

The MIH developed a computer registration system based on bar codes in order to facilitate quick and adequate registration of patient data and enable good medical coordination during a major incident.[3,4]

Three hundred patient numbers are predefined in the permanent Hospital Information System (ZIS) and translated into bar codes. These unique numbers stay with the patient and enable accurate record-keeping, until discharge from the MIH.

Barcodes in the EAN-128 Application Identifier Standard format are used. European Article Numbering (EAN) is an extension to the former UPC (Universal Product Code) and is internationally applicable, exchangeable and unique. An application identifier is a prefix code that is used to identify the meaning and the format of the data that follows it (data field).

Using this PBR, essential data can easily be added by either entering free text or by using the barcodes with predefined codes at any station in the network or with a handheld scanner.

This system also supports quick patient triage and patient tracking within the hospital.

Where ever possible, barcodes are used to ensure rapid data registration and accuracy. Upon arrival, patients receive a barcode wrist band . This will be read by the handheld scanner (*Figure 4*). Triage urgency, medical indications and destination within the MIH are entered from a template (*Figure 5*). This procedure is repeated at each different location in the hospital and provides a system in which the data are continuously updated and available on request. The number of patients, their locations, injury types and the level of care are immediately discernible on demand. The PBR is completely compatible with the Hospital Information System (ZIS) and can exchange data whenever requested.

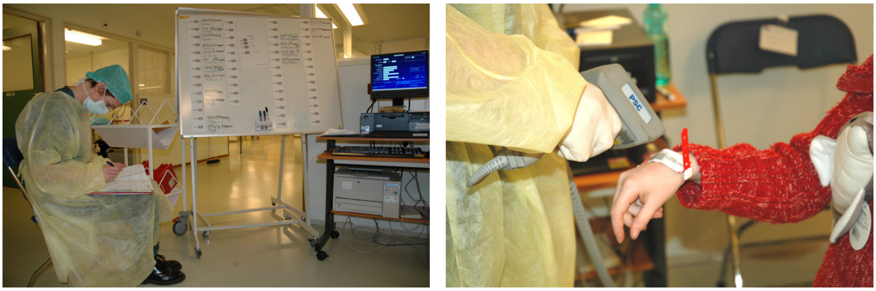

Figure 4. Patient Barcode Registration System: barcode registration with mobile scanner.

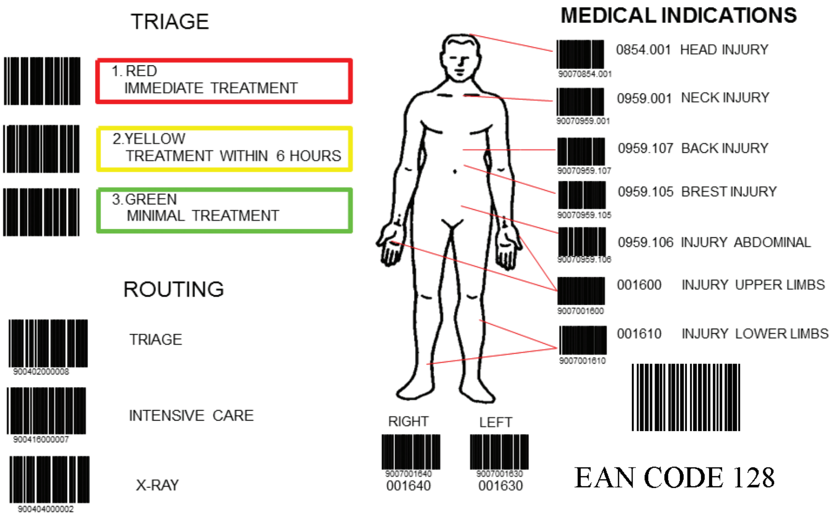

Figure 5. Patient Barcode Registration System: templates facilitate quick and accurate registration of diagnoses, urgency, routing, and medical procedures

Patient flow; triage to successive echelons of care

Victims enter the MIH through the ambulance hall. There they are screened by the triage team consisting of a nurse, a trauma surgeon and two administrative employees. The latter two workers ensure that registration is performed through the barcode on the wrist band and create a digital ID picture of the patient whilst triage is performed by the other two. A four-scale triage system (derived from other four- or five-scale triage systems[2,5]) which is the triage system most widely adopted in the Netherlands is used to define the urgency. Based on the designated urgency (triage) the patient is assigned to a corresponding area (*Figure 2*).

The corresponding areas are described as follows:

- Priority 1: Patients with life threatening injuries that require immediate life-saving treatment are directed to the red bay of the Triage and Treament Area
- Priority 2: Severe injuries that must be treated within 6 hours; the patient is directed to the yellow bay
- Priority 3: No life threatening injury – only minimal acute treatment is needed; patients are directed to the green bay (if the amount of victims exceeds 100, this area can be expanded)
- Priority 4: Deceased victims are transported to the temporary morgue.

After initial triage and primary survey, patients are admitted to one of the following care facilities: the intensive-care department (12 beds), medium-care department (30 beds) or the low-care department (200 beds). Major acute surgical procedures are performed in the regular academic hospital. However the MIH has its own operative facility which can be used for operative therapy, which is especially useful in quarantine circumstances. A good example is the care of repatriated tsunami victims in January 2005.[6] Delayed surgery is also performed in the MIH, when patients have been stabilized and an overview of the population has been gained that allows resources to be allocated appropriately. Conventional radiology, such as X-rays and ultrasound, can be performed within the MIH. The resources of the academic hospital (UMCU) are used to perform MRI or CT-scan, although such scans take very low priority during mass-casualty events. Once the influx of casualties has ceased, reassessments are performed and further treatment is initiated, such as surgical debridement of wounds. Patients that need long or extensive definitive treatments can be transferred to other facilities as soon as possible in order to clear the MIH. Depending on the characteristics of the incident and the results of the screening for potential contagious or resistant organisms such as MRSA, this period can last from one to several days.

Security and communication

Whilst the Command Team focuses on organizing the relief and treating the victims in the MIH itself, a separate Management Team is responsible for external logistics, the continuity of the care in the CMH and the UMCU, internal and external communication and the organization of the initial relief for family/relatives (*Table 2*). The MIH and its surrounding premises are restricted area and are secured by the UMCU Fire Department and the UMCU security services. Communication around the MIH is supported by telephone, fax, the national emergency telephone network, port phones, radio, the Internet and television.

Table 2. Dual command structure

Command team	Management team
Medical manager Major Incident Hospital	Director Personnel and Organization UMCU
Staff Major Incident Hospital	Representative on call for the Board of the UMCU
Location Manager ER UMCU	Commanding officer CMH
Staff IC Unit / Clinical Toxicology UMCU	Head Public Relations department UMCU
Head fire department UMCU	Head Facility UMCU
Head Psychiatric Consultative Department	

Relatives are accommodated in the conference centre of the UMCU and are supported and regularly informed by members of the Social Work and Public Relations departments in cooperation with volunteers from the Red Cross. They are informed about general procedures. When specific information concerning the patients is made available through the Command Team, this is given to the relatives on an individual basis.

The management team directs questions and phone calls from outside the hospital about possible victims. The press is not admitted onto the premises of the MIH and is addressed after informing relatives through press releases and a press conference given by a designated spokesman. Passing information about individual patients onto the press is prohibited.

Patients and relatives are psychologically supported by psychiatrists, mental health workers and volunteers from the Red Cross. After the immediate relief and short-term admittance, the MIH functions more as a central contact point and can provide patients with additional support or referral through the UMCU/CMH. During the relief of repatriated tsunami victims in 2004-2005, the MIH, UMCU and CMH developed an Internet site for follow-up and an international survey on its emotional impact in collaboration with the Department of Social Sciences of the University of Utrecht. This site contains a web-survey, a forum and e-Consult. An Internet based continuous follow up system for incident casualties and their families is currently being developed.

Disasters and major incidents have been shown to place an emotional strain on not only casualties and their relatives but also relief workers, even after indirect exposure through contact with survivors.[7] Therefore psychological care for the personnel involved is provided by the presence of a psychiatric nurse during the relief. Debriefing together in the presence of psychological health workers has been shown to be an important part of dealing with the psychological impact of major incidents. A personnel relief team is available for aftercare, 24 hours a day if necessary.

Evaluation, improvement and research, training.

Preparation is the key to success. We try to improve our preparedness in three ways:

1. Debriefing, evaluating and improving: is performed after each event to discover weak points in the system and to improve performance.
2. Research into relatively new threats concerning biohazards and contagious diseases is constantly performed by the NIVC. Efforts are not only directed at medical research but also at developing registration systems and ameliorating communication systems throughout the chain of (major) incident management. This has for example resulted in the PBR and a Patient Tracking System.[3,4]
3. Last but not least, education and training play an important role in the MIH. Regular theoretical classes, case exercises and disaster simulations within the MIH or together with the whole chain give us a chance to learn, exercise, get to know each other, and to test and adapt.

Discussion

The military as well as surgeons traditionally play an important role in disaster response. In the MIH we hope to get the best of both worlds by integrating them and more into one facility. The training and skills of surgeons and military personnel as well as and the resources and infrastructure of a trauma centre and national poisoning centre are especially well suited tp providing a starting point when preparing for the logistical demands and rapid decision-making required by large casualty burdens following both natural and manmade disasters.[8]

The fact that the MIH is strictly reserved for this type of care guarantees availability of resources when needed and creates time during dormant times to address preparation, training and research. It can provide a buffer for other hospitals against the surge of victims directly after a Major Incident. The intent is to minimize the impact on normal care and to create order in a frequently chaotic situation. If patients need long and definite treatment, they can be transferred to other facilities in a controlled and prepared manner. Keeping casualties together as a group allows us to focus resources of specialized medical resources and expertise, direct psychological support to patients and relatives, address the media, and finally record data in order to learn for the future.

Reserved, group wise treatment in the MIH has other implications in terms of availability besides dormant readiness. It also facilitates the accommodation of patients and frees up the use of operation rooms and other facilities such as radiology and ICU with respect to possible contamination by organisms or agents.

The incidence of MRSA in the Netherlands is lower than 1% whereas approximately 4.7% of the patients repatriated to a Dutch hospital are carriers of MRSA, and 18.2% are carriers of drug-resistant microorganisms.[9] Therefore, a strict quarantine policy is followed in the Netherlands for all foreign patients to rule out potential colonization with MRSA and other multi-resistant bacteria and to prevent transmission to other patients or healthcare workers. This would otherwise delay repatriation, especially when there are a large number of patients, as multiple hospitals would have to be utilized in order to create enough quarantine units. New developments in MRSA screening e.g. the development of a rapid polymerase chain reaction (PCR) test, may greatly shorten the quarantine times of patients with an elevated risk of carrying MRSA. In January 2005, 23 tsunami victims were repatriated to the MIH. Cultured bacteria have often been shown to be multi-drug-resistant, and two out of 23 patients were found to be carriers of methicillin-resistant Staphylococcus aureus (MRSA).[6]

We have four separate isolation boxes and room for 30 patients in strict containment. However, the present infrastructure prevents us from accommodating a group with highly contagious diseases at the same time as patients from another incident. We are working on adapting this to enable us to handle two different scenarios at the same time.

The infrastructure and set up of the MIH aims to provide versatile usage in different scenarios. Although multiple- or mass-casualty incidents are always sudden, unexpected and unpredictable, they can and have to be anticipated. Different mechanisms of disaster will require different needs and approaches, and will produce different patterns of injury and mortality.[10,11] Therefore, in the MIH, several scenario-based plans are available and are continuously researched, trained for, and updated according to the current possible threats. They provide support for approaches to the preparation, activation and management of both logistics and medical care rather than a strict protocol.

Earlier experiences showed that victims are often already on their way to the hospital before the announcement has reached the receiving hospital. Valuable time is then lost by implementing a warning system where personnel on call would have to spend time on warning others, and a standard telephone call tree is not stoppable. The automated warning system of the MIH enables continuous monitoring of the results and the response. Overwarning can be prevented by stopping or adapting further recruitment of personnel according to the results of monitoring. Preset groups of staff make it easier for the Command Team to select an adequate combination of targeted personnel, but a free combination of single employees or a selective start-up is also possible. The system is supported by the reserved capacity of the phone network, which allows the often inundated regular (mobile) network to be bypassed.[12,13]

Providing the greatest care to the greatest number of patients is the major goal of disaster management, and this depends on triage.[2,5,14] Selecting and separating patients who will benefit the most from immediate care begins with field triage on the scene and communication with the receiving hospital; however this part lies beyond the scope of this article. After this primary triage, patients must be triaged at each stage of care. We tried to adapt the infrastructure and organization of the MIH to serve secondary triage according to patient flow through different echelons of care, in order to select the right people from a big crowd for the right amount of care, irrespective of the nature of the incident. Triage at the door is done by an experienced surgeon as it takes experience to accurately assess injuries and determine the resources required versus their availability.[5,14,15]

The use of different colored caps in the teams at each echelon of care facilitates recognizability irrespective of personal acquaintance, and emphasizes role distribution among personnel that do not work together on a daily basis.

To know who is wounded, to what extent they are wounded, and where she/he is, are ongoing challenges in managing multiple casualty events.[12] Achieving an effective response requires real-time information to assess needs and available resources and to deliver the greatest and appropriate level of care to the greatest number of patients.

The PBR system delivers continuously updated group and patient data and permits a real-time overview. Missing data can be added later on, without any prerequisites. Despite the larger number of items entered into the system, it still showed 25% fewer inaccuracies when compared with handwritten medical charts.[4] PBR in the MIH resulted in a clear improvement in medical, nursing and logistic performance when receiving and treating groups of casualties. Extensive training proved to be unnecessary.[3,4]

Providing infrastructure, resources and a plan is not enough. The personell and their skills in several fields, such as triage, decision-making, and communication determine the outcome to a large extent.[1,2] Therefore training and research, performed both within the MIH and throughout its region and affiliated services, is a key task of the MIH. The fact that the core staff have disaster medicine as their core business ensures continuous involvement in training and development. This stops training and preparation for unexpected disaster from always losing out to the daily, more obvious demands of a busy hospital. Not only do they train themselves, but they also train their colleagues in the CMH and UMCU on a regular basis. Working in the CMH/UMCU also ensures that their regular medical skills (i.e. that are not specific to disaster care) are kept up to date.

Conclusion

Major incidents and disasters cause chaos and pose a huge challenge in terms of delivering the best care to the greatest number of people. The Major Incident Hospital (MIH) in Utrecht (the Netherlands) is a globally unique facility that can provide immediate emergency care for multiple casualties under exceptional circumstances. Resulting from the cooperation between a large academic medical institution, a trauma centre, a military hospital, and the NVIC, the MIH offers not only a good and complete infrastructure, but also the expertise required to provide large-scale emergency care during disasters and major incidents. Considering our continuous drive to improve the care for the critical ill, education and training of staff will play a crucial role in the future. Within these training programs, evaluating, researching and learning lessons from the past and the literature are mandatory tasks if we wish to obtain a higher level of care within our MIH.

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Chapter 3

Evaluation of admissions to the Major Incident Hospital based on a standardized protocol

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Abstract

Introduction

The Major Incident Hospital (MIH) is a unique facility strictly reserved to provide immediate large-scale emergency care for victims of disasters and major incidents. We evaluated the implemented organization to identify strengths and weaknesses, and provide knowledge essential for further improvement of preparedness.

Method

According to the Protocol for Reports from Major accidents and Disasters (PRMD) and along with our five scenarios for activation, we analyzed all the data from evaluation reports of all our deployments since the MIH was founded in 1991.

Results

The MIH was able to provide group-wise emergency care to military (29 admissions) as well as civilian victims of major incidents and disasters, both national (260) and international (226). Group-wise treatment was advantageous for quarantine, logistics, registration, emotional support and (pre)arrangements for family, media and security. Strong points are preparedness and availability of a dedicated facility, including ICU, X-ray and OR facilities, irrespective of MRSA status and prearranged cooperation, e.g., with a trauma centre, poison centre and the military. Evaluation, research and training resulted in a barcode registration system and continuous adaptations to improve preparedness. Shortage of resources did not occur; use of the MIH's available resources for national incidents though, could be further optimized.

Conclusions

Recommendations for the future are improvement of imbedding in regional and national procedures; continued dedicated time and staff for training, research and development; improvement of nuclear/biological/chemical decontamination facilities and preparedness; implementation of standardized scoring systems and expansion of registration systems to the prehospital setting.

Introduction

A disaster or major incident causes a sudden, unexpected surge of casualties. In general, disasters produce physical injury. Medical management does not simply involve treating these like in regular trauma care in upscaled proportions, but requires a paradigm change in concepts, approaches and mindset[1]. Preparation and training is essential to cope with the challenge of providing optimal care and to minimize excess morbidity and mortality[1, 2].

Since 1991, the Netherlands has had a Major Incident Hospital (MIH) to provide immediate medical emergency care for multiple casualties under exceptional circumstances. This unique facility is strictly reserved, with expertise and complete infrastructure waiting to provide large scale emergency care with disasters and major incidents[3].

Its missions are divided into five scenarios indicating deployment:

1. War (threat), crisis or conflict management in which large numbers of casualties need care
2. Accidents abroad involving Dutch citizens, civilian or military, in need of repatriation and medical care
3. Specific incidents, attacks or large-scale accidents in the Netherlands that exceed the regular care capacity
4. International medical assistance from the Dutch government concerning the treatment of foreign victims
5. Quarantine care for patients with special infectious and highly contagious diseases, such as SARS (Severe Acute Respiratory Syndrome).

The opening of the MIH is an essential part of the disaster plan of the University Medical Centre Utrecht (UMCU) and the Central Military Hospital (CMH). The MIH is located in a nuclear bunker under the UMCU, which is in turn connected to the CMH by a corridor. An Emergency Response Protocol enables admittance to the normally dormant hospital of up to 100 patients after a start-up time of only 15 min. With an additional 45 min the patient count can be extended to 300. Personnel are alerted through a personnel alert system. The organization, infrastructure and training are all directed around triage to guide patient flow through successive echelons of care in order to deliver the greatest care to the greatest number of people (*Figures 1, 2*). The Patient Barcode Registration System (PBRS) with European Article Numbering (EAN) codes guarantees quick and adequate registration to facilitate good medical coordination and follow-up during a major incident.[4]

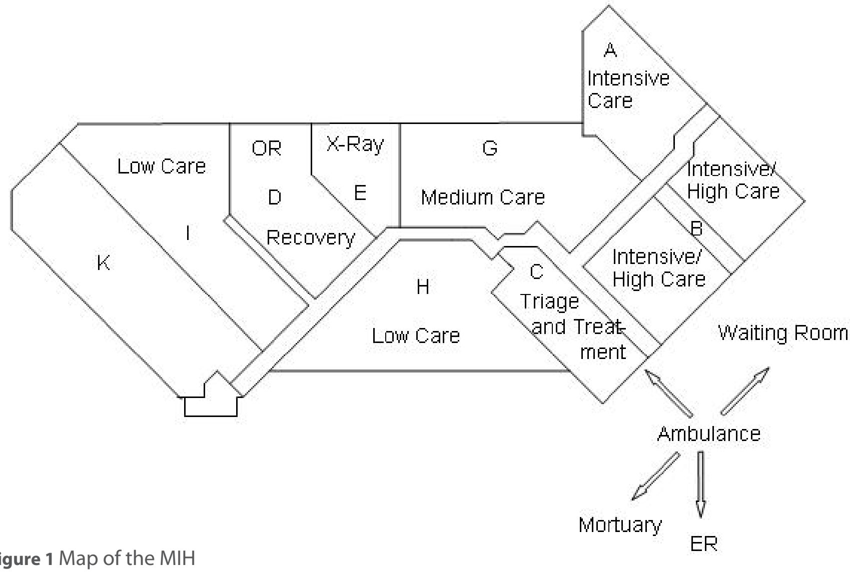

Figure 1 Map of the MIH


Figure 2 Entrance of the ambulance hall of the MIH

As analysis of the implemented organization and clinical management could identify helpful decisions and errors, we evaluated the use of the MIH and its admissions during the past 19 years. Research and evaluation of past incidents provide knowledge for preparedness and response to unknown future incidents and are essential for further improvements.[5] Systematically evaluating the quality of medical response to major incidents is difficult, though, especially because of obvious differences in the types of disasters and a wide variety in modes of evaluation. Furthermore, there is no standardization of reporting yet. Performance indicators for the quality of the medical response are scarce but have been evolving in the past decade. Critical mortality rate (the percentage of severely wounded victims who die), for example, gives an indication of the magnitude of the disaster and of the effectiveness of the medical management.[5,6] To evaluate the performance of the MIH, however, this tool would be too general and more reflective of the performance of the total of disaster response than of hospital care alone. Ruter et al. suggest a set of 20 performance indicators that they applied to 13 earlier reports on major incidents issued by the KAMEDO organization in Sweden.[7] These consist mainly of timeframes for decisions and actions at the scene and at the level of command and control, predominantly prehospital. They also developed some performance indicators for testing the skills of hospital management groups in simulation exercises.[8] Some indicators of preparedness, not performance, have been used to evaluate US trauma centre preparedness.[9] The Utstein template[10] also suggests a method for a more scientific approach. For this goal, it seems too elaborate and theoretical. Lennquist suggested a template to report major incidents, the Protocol for Reports from Major accidents and Disasters (PRMD).[11] It offers a standardized methodology for reporting results and experiences from major accidents and disasters to improve comparability. It facilitates exchange of experiences and promotes international collaboration in methodological development. The protocol is divided in 18 headings concerning components of the incident as well as of the response, complemented with standardized tables. Although originally developed to evaluate and report about individual major incidents, it offers us a concise and practical template to direct the evaluation of the MIH deployment, as well as a standardized method for reporting.

Objective

In this study, we evaluate the use of the MIH since its founding in 1991, according to the PRMD[11] and along with our five scenarios for activation. Further central questions were: how did we perform in the five openings scenarios? What are the strong points in group treatment? Which changes led to identifiable and sustainable improvements? Was the MIH effectively used in the whole chain of disaster management? What are our recommendations for the future?

Materials and methods

Our evaluation concerns the performance of the MIH itself. Inclusion of the prehospital evaluation for 34 incidents is beyond the scope of this analysis.
We retrieved all data from the evaluation reports of every MIH deployment since its founding in 1991. Reports had been made directly after the event as part of the debriefing in almost every admission, and had been discussed among involved disciplines for learning points and accuracy. One of the authors (JvdE) participated in all admissions and evaluations until 2008 except the repatriation of fugitives from Kosovo (1999). Missing data were retrieved retrospectively from the charts and medical files. These files had all been kept on paper within the MIH.
Demographic and quantitative data were registered (such as number of patients, types of injuries, hospital resources). All applicable data were registered according to the PMRD protocol[11], which is divided into 18 headings that we used to direct our evaluation (*see Table 1*). The standardized tables from the protocol were used, sometimes extended with additional columns. For qualitative, descriptive values we abstracted the results of all admissions and further discussed admissions which revealed the most interesting learning points.

Results

The subheadings in this paragraph are analogous to the 18 subheadings of the PRMD.

1/2/3 Summary of the scenario/hazard, description of accident

All 34 consecutive deployments of the MIH are depicted in *Table 2*, summarized with short descriptions of each event and the type of activation scenario. Military victims (29) accounted for 5% of the admitted patients and 18% of the deployments. Two hundred and twenty-six (38%) Dutch victims of major incidents abroad were repatriated in 12 group admissions, whereas national incidents accounted for 260 patients (47%) and 35% of the deployments of the MIH.

Table 1 Headings from protocol for reports from major accidents and disasters[10]

	Headings	
1	Short summary of the scenario	*
2	Desciption of hazard(s) causing the accident	*
3	Desciption of the accident	*
4	Prehospital resources available and alerted	
5	Hospital resources available and alerted	*
6	Utilization of transport resources	
7	Hospital alert plan and response	*
8	Coordination and command	*
9	Hospital damage	*
10	Communication system	*
11	Computer Technology and back-up systems	*
12	Total number and type of injuries	*
13	Severity of injuries	*
14	Hospital load	*
15	Psychological reactions	*
16	Outcome	
17	Estimated number of people affected but not injured	
18	Post-accident evaluation	*

* =data available for analysis

The rest consist of 4 openings to offer care for foreign incident disaster victims (44 patients, 10%). Special infectious disease admissions did not take place. For national incidents the distances from the scene to the MIH (0.3–60 km) are also depicted in *Table 2*.

Table 2 Overview of use of the MIH; year, number of admitted patients, short description of the incident, distance (km) from the scene, cohort quarantine and main type of scenario for deployment of the MIH

Year	Number of patients	Incident characteristics	Distance, or country if abroad	Quarantine /Main scenario (*)
1991	9	Methylbromide intoxication (used by gardners decontaminating glasshouses)	45 km	no/3
1991	9	Carbonmonoxide intoxication; insufficient boiler	5-10 km	no/3
1992	10	Carbonmonoxide intoxication of fireman on duty	5-10 km	no/3
1992	5	Exposure to nitrous damps	5-10 km	no/3
1992	28	Evacuation of a hospital in a war setting (Bosnia Herzegovina)	Bosnia	yes/4
1992	13	Plane crash (Faro) with a fire	Portugal	yes/2
1993	43	Bus accident (Lyon)	France	yes/2
1993	5	Evacuation of a hospital in a war setting (Bosnia Herzegovina)	Bosnia	yes/4
1994	4	Busaccident (Regensburg, Germany)	Germany	yes/2
1995	143	Evacuation of a flooded Hospital	52 km	no/3
1995	7	Benzylbromide exposure (Utrecht)	5-10 km	no/3
1996	29	Bus accident of Dutch singing choir (Winterberg)	Germany	yes/2
1996	12	Cannabis intoxication (Zeist)	8 km	no/3
1996	6	Aluminium pollution of fluids in dialysis centre	Curacao	no/4
1996	11	Bus accident (Antalya)	Turkey	yes/2
1996	15	Carbonmonoxide intoxication; inadequate boiler	5-10 km	no/3
1996	10	Bus accident of tourist bus from Netherlands (Thionville)	France	yes/2
1997	7	Military accident (Novi Travnik, Bosnia Herzegovina)	Bosnia	yes/1
1997	13	Bus accident	Syria	yes/2
1998	20	Bus accident of tourist bus from the Netherlands (Metz)	France	yes/2

Year	Number of patients	Incident characteristics	Distance, or country if abroad	Quarantine /Main scenario (*)
1999	5	Repatriation of fugitives	Kososvo	yes/4
1999	12	Earthquake, Turkish Dutch residents on holiday	Turkey	yes/2
2000	9	Military accident	Germany	no/1
2002	25	Busaccident of tourist bus from Netherlands (Metz, France)	France	yes/2
2002	21	Busaccident of tourist bus from Netherlands (Manching, Germany)	Germany	yes/2
2003	13	Labaccident, glue-damp with eye/airway irritation (methylmetacrylate)	0,3 km	no/3
2005	25	Repatriation of wounded Dutch Tsunami victims	Asia	yes/2
2007	6	Collapse of a crane on campus building	0,4 km	no/3
2007	4	Repatriation of soldiers from Afghanistan (victims of a suicide bombing)	Afghanistan	yes/1
2008	25	Evacuation 350 employees from contaminated building (unknown substance)	23 km	no/3
2009	6	Airplane Crash near Schiphol airport ("Polder Crash" with, 135 passengers)	60 km	no/3
2009	4	Repatriation of military victims Afghanistan	Afghanistan	yes/1
2009	2	Repatriation of military victims Afghanistan	Afghanistan	yes/1
2009	3	Repatriation of military victims Afghanistan	Afghanistan	yes/1
Total	559			

(*) Scenario's for activation of the MIH: (1) Military victims, (2) Repatriation of Dutch victims of accidents or incidents abroad, cohort-isolation for Methicilline Resistant Staphylococcus Aureus (MRSA) according to guidelines of the Netherlands Health Care Inspectorate, (3) Activation of the MIH for a national Major Incident or disaster, (4) International medical assistance from the Dutch government concerning the treatment of foreign victims, (5). Quarantine care for patients with special infectious and highly contagious diseases e.g. SARS. For international deployment Evaluation of admissions to the Major Incident Hospital based on a standardized protocol the country of repatriation is depicted, at distances varying from several hundred to thousands of kilometers.

4. Evaluation of "Prehospital resources available and alerted"

lies beyond the scope of this report

5. Hospital resources available or alerted

As the MIH is a reserved facility for major incidents, availability of triage rooms (35 beds), low and medium care beds (200), ICU beds (12), ventilators, radiology unit, operating theaters and trauma unit is guaranteed. (*Figures 3, 4, 5, 6*). Usability is dependent on the ability to staff them. In all evaluated deployments, staffing has never proved to be a problem; the capacity could always be operational for the first 100 beds within 15 min to half an hour. Training issues of deployed staff are discussed below.

Figure 3 Low care unit in dormant times

Figure 4 Low care unit in use

Figure 5 Triage and treatment area
(photo B. de Meijer)

Figure 6 Triage and treatment area-red bay, stabilization of a patient
(photo B. de Meijer)

In the evaluation of optimal use of resources, situations in which the MIH was available but not deployed are particularly interesting. An example is the Volendam cafe´ fire on New Year's Eve, 2001, where 98 victims were transported to 20 hospitals and 100 victims went to different ERs of hospitals on their own. Four people died. The MIH was alerted 7 h after the incident with the request to receive two burn patients that could be regularly admitted to the UMCU. In total 11 patients were admitted to the UMCU. Numerous patients were transferred to a widespread variety of hospitals and it took a full day afterwards to get an overview. A bus with 20 T3 victims (in the four scale triage system[12]) was sent to a hospital that turned out to have no capacity left and had to divert to another hospital.[13] The MIH could have better contributed to care and simplifying patient logistics had it been deployed in an earlier stage. The collapse of stairs during a musical parade in 2008[14] is an example where 19 patients were seen in one trauma centre and the MIH was not deployed. Medical management went well and was within surge capacity of the hospital. In this case, using the trauma centre or MIH were both good options and the choice was a matter of preference of the staff on call. Using the MIH for first relief would have eased logistics and communication with supporting facilities that were now problematic due to provisional patient numbering.[14]

After the plane crash near Schiphol ("Polder Crash" 2009), 42 of the 135 victims patients were transported from the triage site by bus to a sports complex after being triaged as T3. They were spread to several hospitals and it took 4 days to reconstruct the victim list and whereabouts of the patients.[15] Only six patients were transported to the MIH.

One of the other specialties of the MIH is relief of groups of patients in quarantine, which otherwise often generates logistic problems and delay of repatriation to regular hospitals.

In 1994, a group of Dutch victims from a bus accident in Poland were repatriated to a city hospital instead of to the MIH due to political choices of the hometown government, despite prior alert and readiness of the MIH. This resulted in a forced temporary closure of the regular surgery and orthopedic departments due to MRSA contamination.

In the Faro plane crash in 1992, 95 patients were repatriated to 6 hospitals including the MIH. Eight (8%) proved to be infected with MRSA. This corresponds with 14% of the MRSA category II patients (patients with minimum 24 h stay or invasive procedures in a foreign hospital). This led to secondary spread to other patients and staff in one of the Burn Centers.

Repatriation in quarantine from Thailand to the MIH after the 2004 tsunami showed several carriers of MRSA and other multi-resistant microorganisms.[16]

Repatriations of military victims from Kosovo and Afghanistan to our facility also showed multiple victims with MRSA and *Acinetobacter* colonization.

Of all the quarantine admissions, 61% or more of the patients could be discharged home within the 5 days that are set as a directive to close the MIH, or quarantine could be ended due to negative swabs. Transfers under quarantine conditions were reduced to 32% of the patients who were initially treated in quarantine.

During the SARS threat we adapted our facilities and training to prepare for patients with special highly infectious diseases. Since 2003, the MIH has changed the air treatment and can provide 4 isolation boxes and 30 medium care beds for this type of scenario.

6. Utilization of transport resources

Was not applicable/evaluated

7. Hospital alert plan and response

Opening of the MIH is always based on activation of the local disaster plan. When the Emergency Response Program is started, the medical manager of the Emergency Room activates the personnel alert system through the national civilian telephone network. This system has specially reserved capacity for use by the disaster management chain. During all deployments, communication through this system was never hindered by the inundation of the regular mobile network, as often occurs in disaster situations. In contrast to a normal, time consuming "calling tree", results are monitored and adjustable once running, as personnel respond to the system if and when they are available. This system enabled us to tailor the alert. At first, we worked with different lists adapted to several scenarios but these had too much overlap. In the current system, we can compose the alerted staff by choosing and combining groups, e.g., "base", "surgery", "anesthesia" etc. The system is tested every 6 months for effectivity and to keep numbers updated. Alerts resulted in an average direct availability of 50%, with slightly lower rates at night. Under-alert has not occurred, except for two cases were the radiology department was not included in the initial call. Over-alert was the case in the Polder Crash (2009).[15] Within 45 min after the crash we contacted the regional command center dealing with the crash to inform them that we were available to receive patients within half an hour. This was after seeing the information on the Internet and after the UMCU had been alarmed by the regional ambulance service. In fact, the MIH was never formally approached or informed by the central coordination centre nor by the national crisis team. The MIH was opened based on controversial information from the scene and a second alert from the regional ambulance service that the first four patients were already on their way to our centre. One hundred forty-three staff members were alerted, of which 39 were deployed and the rest were sent home. Finally, only six patients (four T2 and two T3) were transferred to our hospital.[15]

8. Organization of coordination and command

Evaluation of preparedness and function scores of all prehospital units of the response chain lies beyond the scope of this report.

For the MIH, the trauma surgeon on call is fully licensed to open the MIH, which benefitted opening speed. Hereafter, a dual command system is implemented. This means that the Command Team focuses on organization of the relief and treatment of the victims in the Major Incident Hospital itself, and a separate Management Team is responsible for external logistics, continuity of the care in the CMH and UMC, internal and external communication and the organization of first relief of family/relatives. This proved to keep the Command Team alert and in control and prevented distraction by external business beyond patient relief.

9. Hospital damage due to a disaster was never the case

Admission of 13 patients with an inhalation problem from the UMCU laboratory and the collapse of the crane on the same university campus were the nearest scenarios.

10. Communication system

In the beginning, team leaders carried portable phones. This proved distracting as it generated a lot of (unnecessary) use and people did not always know how to use them effectively, not being accustomed to them in the daily setting. We abandoned them (apart from ambulance hall) and chose regular pagers. This resulted in strict reserved use and effectivity. After 1992 the PBRS provided continuous and updated group and patient data in every area and at every working station in the MIH. This resulted in clear improvement in medical, nursing and logistic handling and covered many of the communication needs. It enabled staff to better anticipate and manage care requirements and effectively use resources and personnel up to discharge[17]. Short "chief meetings" took place at regular intervals. During these meetings, the operational unit supervisors discuss all crucial steps with the command team and make logistic decisions and other arrangements between all participating units, ranging from security to operation rooms. The supervisors return to their units to implement the decisions. This proved very effective in sharing information and plans quickly and greatly simplified procedures to get things done and manage the entire organisation.

11. Computer technology and back-up systems

We did not encounter major computer system failures during admissions. Regular exercises in the MIH helped us to improve ease of use. A backup system is present but has never been used. The PBRS that we developed showed 25% fewer inaccuracies when compared with the handwritten medical charts, despite the greater number of items entered [17]. Extensive training proved to be unnecessary. (Para-) medical personnel judged the automated procedures an improvement. The coupling with the Hospital Information system worked well. The follow up chart of patient care in the MIH is not computerized, yet; that is a goal for the future.

12. Total number and type of injuries

Total number and type of injuries are depicted in *Table 3*. Almost half of the patients (254, 45%) were admitted with injuries due to mechanical violence. Inhalation accounts for 16% (93) of the admitted patients.

Table 3 Total number and type of injuries

Type	Number of injured
Mechanical violence	254
military (29)	
non-military (225)	
Fire	13
Inhalation	93
Methylbromide (9)	
Carbonmonoxide (34)	
Nitrous damps (5)	
Other (45)	
Corrosive agents	0
Irradiation	0
Cold	0
Drowning	0
Biological contamination	0
Other	199
mixed hospital population, external evacuation causes (war, flooding) (181)	
cannabis intoxication (12)	
aluminium intoxication (6)	
Total	559

13. Severity of injuries

All patients were triaged on admission. Except for triage on admission, we did not use a standard scoring system as for example, the Injury Severity Score (ISS). Severity of injuries according to treatment is depicted in *Table 4* and was relatively low (as well as retrospectively estimated ISS above 15). Most patients (95%) were triaged at priority 2 or 3. Intensive care use (4/559 = 0.7%) and ventilator dependency were scarce (4/559 = 0.7%), as was need of immediate surgery (defined as within 1 h) (0%).

Table 4 Severity of injuries according to treatment

Type	Number		
	Repatriation	National incident	Total
Less severe injuries not examined or treated by medical professionals (a)			n.a.
Less to moderately severe injuries examined and/or treated by medical professionals (a)			
outside hospital			n.a.
in hospital	2	13	15
Injuries requiring in-hospital care/observation in	297	247	544
regular ward	289	175	464
medium care	4	72	76
intensive care	4	0	4
requiring ventilator	4	0	4
Injuries requiring surgery (general anaesthesia)	31 (*)	0 (*)	31(*)
immediately	0	0	0
within 6 h	7	0	7
Delayed	24 (*)	0 (*)	24(*)

(a) medical professionals defined as ambulance staff, paramedics, nurses and doctors
n.a. not applicable
(*) in 4 admissions several additional delayed surgery procedures in referral clinic

14. Hospital load

Congestion, lack of material, resources or personnel influencing optimal patient care did not occur in any of the deployments. Volunteers from the Red Cross that assisted in patient care and transport within the MIH proved to be a valuable addition to the professional pool (*Figure 7*). Discharge and transfer procedures were delayed and sometimes congested because often many patients were discharged at the same time and discharge papers had to be prepared, which requires staff time. Therefore, in 1999, we developed an automated patient discharge letter system and appointed one person in medical staff to supervise this. This improved the discharge process, resulting in no more delays.

Fig 7 Patient transport by volunteers of the Red Cross *(photo B de Meijer)*

15. Psychological reactions and management

In every admission, staff members from the psychology and psychiatric department are available to provide psychological support for victims, relatives and staff. They are supported by volunteers from the Red Cross who assist patients in personal care and offer a listening ear. If desired, the team can provide referral advice for support after discharge. Patients rate this as very positive in patient evaluations. Being among peers was perceived to be supportive and contributing to resilience. Long term evaluation among the repatriated tsunami victims showed that need for professional support often arises at a later stage than directly after the disaster, sometimes even after months or years.[18] We are currently exploring how we can address this by offering a gateway to professional help through a site that can be accessed at any time after the disaster. In analogy with the site launched after the tsunami (http://www.tisei.org)[19], this site combines self help through mutual victim contact and self-assessment with e-Consult possibilities.
Post-deployment evaluations with personnel showed that they experienced substantially more emotional burden when caring for incident victims than in regular hospital care. This was not determined by severity of wounds or physical trauma but mostly by the impressive stories, emotional reunion of victims with families and (media) attention that comes with major incidents. During victim relief and during shift changes, a consultative psychiatric nurse is present for personnel. An aftercare team contacts them afterwards. Informal gatherings after the admission proved to give more room for sharing emotions and feelings than meetings labeled to address emotional impact.

16. Outcome with regard to mortality and persistent disability

In-hospital mortality was low (1/559 = 0.2%). This concerns a patient that was repatriated from a military mission to confirm brain death and to stop treatment amidst his family. Persistent disability was not scored and was difficult to quantify, as the MIH is a short-term facility that closes after a few days. Opening time ranged between 1 and 5 days. Clinical patients were then transferred to other hospitals and follow-up of outpatients was done mainly in the home city hospitals. From the 559 patients, 256 patients (46%) were transferred to other hospitals, while 303 (54%) could be discharged home within closing time of the MIH.

17. Estimated number of people affected, not injured was not scored

18. Post-accident evaluation evaluation

Post-accident evaluation evaluation of preparedness
The disaster plan is the basis for the MIH and was always activated in the case of admissions. The evaluations showed that the basic disaster plan functioned well. Some of the adaptations are described in the above paragraphs. Another important finding in the evaluations concerns preparedness for situations that require decontamination. During the evacuation from a building contaminated with an initially unknown gas in 2008, patients entered the MIH without decontamination. Afterwards, decontamination proved unnecessary as it turned out to be smoke from an aircon fire, but this reinforced reevaluation of the disaster plans regarding when and how to start decontamination procedures. In a training session for decontamination within the MIH, we also concluded that our ability to decontaminate large groups of patients was insufficient. We further extended training and are currently improving the infrastructure and decontamination facilities (*Figure 8*).

Figure 8 training with decontamination in a multi-disciplinary exercise, MIH 2010

Post accident evaluation of training

In the first years, optimal relief was sometimes hindered by the fact that the majority of the alarmed personnel was still relatively unfamiliar with procedures and logistics in the MIH. This mandated the expansion of training activities and starting up a pool of personnel who spend part of their time performing tasks in regular care when the MIH is dormant, but spend the rest of their time outside deployment times on training and preparedness. They now form the basis for training the rest of the pool of dedicated doctors, nurses and support team from all UMCU/CMH departments that can be alerted. Regular theoretical classes, case exercises and disaster simulations within the MIH or together with the whole chain resulted in smoother cooperation and better preparedness (*Figure 9*). In an environment where teams are always assembled from a big pool, and of which a considerable portion is made up of residents that change every 2 years, the intensity of training and a strong base proved crucial.

Figure 9 Cooperation between military and civil services (Ambulance hall MIH)

Discussion

The goal of availability, preparedness and quick performance was met in four of the five deployment criteria of the MIH. A major incident with contagious diseases or material (fifth criterion, added since 2003) has not yet occurred.
In the relief and repatriation of military victims (first scenario) the MIH has proved its surplus value in availability of the total range of care (low care till ICU and OR as well as radiology facilities) without quarantine restrictions and disturbance of regular care. This facilitates quick repatriation and initiation of treatment, which

is often not possible in war/mission setting. MIH staff is partly military and is familiar with repatriation procedures and concurrent emotional impact for patients and family. The same advantages account for civil repatriations (second scenario) in quarantine after incidents and disasters abroad. The Netherlands follows a strict quarantine policy for all foreign patients in order to rule out potential infection with MRSA and other multi-resistant bacteria to prevent transmission to other patients or healthcare workers. This policy is reinforced by recent literature that shows that MRSA types have a predominantly regional distribution in Europe.[20] This finding is indicative of the selection and spread of a limited number of clones within health care networks, suggesting that control efforts aimed at interrupting the spread within and between health care institutions may not only be feasible but ultimately successful and, therefore, desirable.[20] In this evaluation, (MRSA) quarantine has again proved necessary in several deployments and nondeployments. Some examples are discussed above. Groupwise relief in quarantine has the advantage of availability, risk reduction for regular care and reduction of further quarantine efforts. In the quarantine admissions, the majority of the patients could be discharged home before closure of MIH, or quarantine could be ended due to negative swabs. Transfers under quarantine conditions could be greatly reduced and have the advantage of preparation time for the receiving hospital. Preparation time is not only favorable for quarantine issues but time also permitted selection of the most suitable follow-up hospital for each individual patient with regard to expertise and geography. Since the repatriation from the bus accident in Poland (1994), the Dutch policy is to perform all group wise repatriations in quarantine in the MIH.

For the third opening scenario, national major incidents, the deployment of the MIH was relatively low and its availability and capacity were certainly not used to maximum advantage. Distance to the scene might be mentioned as a reason for using other facilities, but in many cases this was not an issue. Utrecht and the MIH are located quite centrally in the Netherlands. For example, in the Polder Crash the MIH was well within 60 km of the accident, comparable to distances to some of the other deployed hospitals. Direct availability for the entire group would have eased logistics.

We think the most important factor is suboptimal embedding of the MIH in the Dutch system of incident relief. The organization of disaster relief in the Netherlands is strongly developing and new liaisons with the MIH are still in progress. The fact that the MIH is not used in regular trauma care might also contribute to suboptimal use of its capacity. The regional medical officer in charge of an incident, as well as the regional command center, might not always be familiar with the advantages the MIH has to offer. The National Coordination centre was not always deployed, although it is appointed for interregional activities and major incidents. Furthermore, hospitals in the affected region, and especially trauma centers, are eager to care for "their own" patients and do what they trained for in trauma care and in their hospital disaster plans. Performance of the regular Dutch trauma centers and hospitals proved to be good for multiple trauma/incident patients in terms of direct care within surge capacity.[14,15,21] Leap-frogging could guard these capacities in not-too extensive incidents, but it also complicates communication, patient overview, logistics, impact on regular care (over and under alert of several hospitals), family support, media and security.[13, 15, 21] The MIH could make a valuable contribution in effective use of all available capacity and delivering the best care to the greatest number of patients. This does not necessarily mean that *all* patients should always go to the MIH. A good distribution could be to transport T1 victims to trauma centers and group T2 and T3 victims to the MIH. This allows trauma centers and local hospitals to focus on T1 victims and unavoidable selfreferrals. Meanwhile the MIH can sort out the bulk, eventually with some of the T1 victims, in a situation that is designed for further triage through successive echelons of care, and where other conditions for good group wise treatment are prearranged, such as reserved availability of resources (100–300 beds; 12 ICU, 38 medium care and 50 low care, OR, radiology, etc.), registration, psychological support, media, family issues and security. This could facilitate prehospital organization and quicker patient overview.[15] In contrast to the situation after the Polder Crash, for example, where completing the victim list took 4 days, institutions have only to contact one hospital with regard to numbers of patients, severity of injury and personal data. The PBRS directly provides a real time overview. Relief for T1 victims is also possible in the MIH, but this patient group benefits most from fast treatment, justifying transportation to the nearest adequate facility. Furthermore, they generally have a longer and more intense treatment path that merits significant and highly qualified personnel and resources. Spreading of these patients among trauma centers can probably guarantee better continuity of care after first relief. For these patients the additional value of being among fellow survivors is less relevant.

Irrespective of the type of scenario, group-wise treatment had several advantages, including mutual support among patients and (pre)arrangements for logistics, registration, family and media.

Looking at the other points we evaluated, communication and computer technologies deserve further development. Although the PBRS functions well and brings unique advantages for real time overview and management, extension of patient registration and tracking to the prehospital setting would be desirable. For this goal we developed a Victim Tracking and Tracing System

(ViTTS), that will be discussed in another paper. Digitalization of the entire medical chart within the MIH would maximize yield of the PBRS, the discharge letter system and would facilitate research.
Furthermore, we aim to implement the ISS[22] for registration of injury severity. This is an internationally used scoring system, useful for categorizing severity as well as for reporting. This would allow easier comparisons, also with regular trauma care and with outcome related to ISS. Among our admitted patients were relatively few T1 patients or patients with retrospectively estimated injury severity scores above 15. This observation has three explanations: In some incidents severely injured patients went to other hospitals (e.g., Polder Crash 2009), in some cases (e.g., crane collapse, bus accident and evacuation of flooded hospital) the incident itself produced mainly T2 or T3 victims, as in most mechanical disasters[23] and finally because some admissions were repatriations with a selected group that was stable enough to travel (e.g., tsunami repatriation).

Conclusions

The MIH has demonstrated its ability to provide group-wise emergency care to military as well as civil victims of major incidents and disasters, national or from abroad, in all scenarios for activation except care for special highly infectious diseases (as this did not occur). Group-wise treatment proved to be advantageous for quarantine, logistics, registration, emotional support and (pre)arrangements for family, media and security. Preparedness and availability, irrespective of MRSA status, including ICU, X-ray and OR facilities and prearranged cooperation, e.g., with the UMCU, NVIC and the military, are strong points. Evaluation and training resulted in developments such as the PBRS and continuous adaptations to improved preparedness.

Key recommendations for further development are:

1. Better imbedding in regional and national procedures to optimize use of availability in case of national disasters; expand involvement of other trauma centers.
2. Continued training, research and development, preservation of a pool of dedicated staff to keep the organization alive and moving.
3. Improvement of nuclear/biological/chemical decontamination facilities, adaptation to external developments.
4. Expansion of the PBRS within the MIH and in the prehospital phase: create fully electronic patient charts and prehospital patient tracking and tracing.
5. Implementation of standardized scoring systems to record injury type and severity to facilitate research and comparability.

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Chapter 4

Online Victim Tracking and Tracing System (ViTTS) for Major Incident Casualties

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Abstract

Introduction

Dealing with major incidents requires an immediate and coordinated response of multiple organisations. Communicating and coordinating this over multiple geographical locations and organisations is a complex process. One of the greatest challenges is patient tracking and tracing. Often, data about the amount of victims, their condition, location and transport is lacking. This hinders an effective response and causes public distress. Therefore, we developed a Victim Tracing and Tracking System (ViTTS).

Methods

Development of an online ViTTS, based on a wireless network generated by routers on ambulances, with direct online registration of victims and their triage-data through barcode injury cards. We tested the system for feasibility and usability during disaster drills.

Results

The formation of a local radio-network of hotspots with mobile routers and connection over GPRS to the central database worked well. ViTTS produced accurately stored data, real-time availability, and a real-time overview of the patients (quantity, seriousness of injury, location).

Conclusions

The ViTTS provides a system for early, unique registration of victims close to the impact site. Online application and connection of the various systems used by the different chains in disaster relief promotes interoperability and enables patient tracking and tracing. It offers a real-time overview of victims to all involved disaster relief partners, necessary to generate an adequate disaster response.

Introduction

With major incidents, the demand for clinical care may exceed the availability of resources. Optimal use of available resources must be achieved through adequate coordination creating "The greatest good for the greatest number of people".[1]
One of the problems we are faced with during disasters is the chaos and the uncertainty. Dealing with major incidents requires an immediate and coordinated response of multiple organisations in which the allocation of various resources over multiple geographical locations makes it a complex decision making process. One of the major issues is the allocation of patients to hospitals and adequate patient tracking and tracing; we often don't know how many victims there are, how serious their condition is and what the status is of their transport. This may result in an ineffective response.
In 2000/2001, just 6 months after the Fireworks disaster in Enschede, The Netherlands was hit again by a new disaster. On New Year's Eve, a fire in a pub in Volendam killed 14 people and injured 245. It took several hours to get an overview of the number of victims and the severity of their injuries. The confusion even persisted after the evacuation from the scene was completed. The registration of patients at the disaster site and in the 19 receiving hospitals was a major problem. Valuable time was wasted with identifying patients and seeking family members.[2]
These problems are encountered and described worldwide, the World Trade Centre Disaster is one of many examples of communication failure with regard to response from different agencies.[3,4] Communication problems were a greater hindrance to an effective response concerning triage, patient movement and hospital preparation than all other factors combined.[5] Also after Hurricane Katrina, the Senate Homeland Security and Governmental Affairs Committee Report concluded that responders' efforts during the crisis were "hampered by the lack of data interoperability".[6]
The core problem can be reduced to an ineffective integration of the different systems. The medical, fire- and police departments, together with the government chain, have their own systems, which are poorly interconnected.
This results in a poor understanding of the three basic elements essential to providing an adequate (medical) response:

Situational awareness

The ability to make timely and effective decisions during rapidly evolving events is highly dependent on an understanding of the situation at the scene and in the response chain. This should be based on accurate and up to date information.

Resource allocation

In case of a major incident or disaster, the demand for clinical care may rapidly outgrow available staff and hospital facilities. Optimised use of available resources must be achieved through allocating transport availability, hospital capacity, shelter or mortuary facilities.

Stakeholder information

In today's real-time information society a major incident will trigger an immediate need for adequate and validated third party information (authorities, relatives, media).

These facts provoked us to initiate the development of a Victim Tracking and Tracing System (ViTTS), to overcome the challenges of adequate victim information in a highly complex and chaotic situation. The tracking and tracing system should serve the following goals:

- Early, unique identification, registration and following of victims during a disaster or Major Incident
- Provide real-time information of the victims (quantity, seriousness of injury), their whereabouts and destination
- Provide early management information to the chain of command
- Guarantee a stable data communication platform, also in case of mass casualty incident situations
- Create interoperability and availability to relevant authorities and participants in the response
- Provide a secured network

This paper describes the (development of) an online Victim Tracing and Tracking System (ViTTS), including results of feasibility tests and usability tests in disaster drills. Its strengths, limitations and recommendations for the future are discussed.

Methods and development of a Victim Tracking and Tracing System

Technical aspects of the system and its components

The ViTTS is a concept to record and exchange information about the status and location of victims during and after a mass casualty incident. It offers an online information exchange network and standards that promote interoperability of existing systems of the various organisations within the disaster management chain.

It consists of a central data bus (*see Figure 1*) that is linked via a local and wide area network to the existing database systems in the disaster management chain. The data bus functions as a "central highway" for data transport. All different local databases (e.g. Police, local council, command vehicle, other non-government organisations (NGOs) and emergency databases are linked to this data bus system. The applications can communicate with the ViTTS data bus through Extensible Markup Language (XML). In 2006 standards were further developed to promote uniform information provision. These are protocols or formats on how data is registered and exchanged between operational services, authorities, hospitals and the ViTTS data bus, which are necessary for good interoperability of the systems.

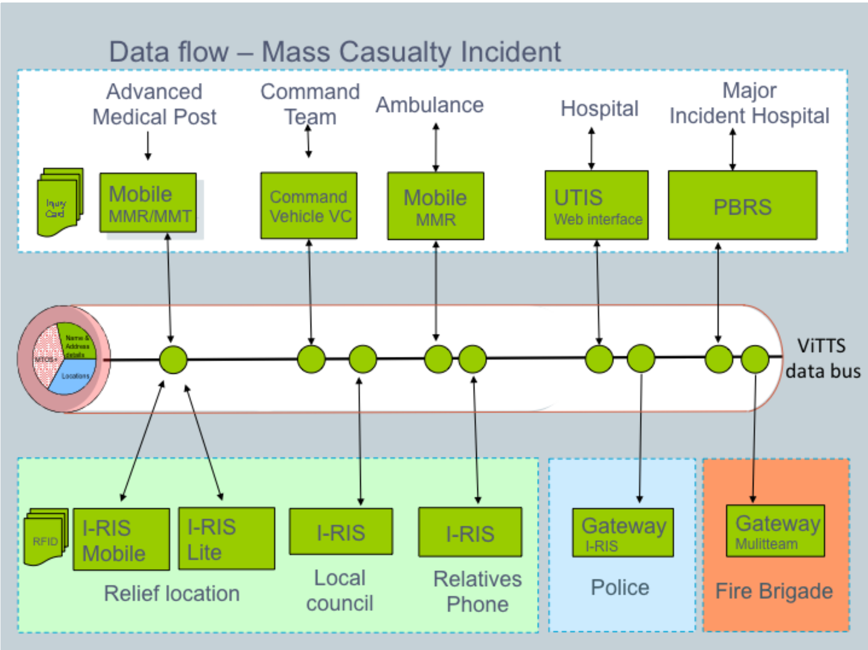

Figure 1. Technical lay out of ViTTS: dataflow. The systems of all partners in disaster relief are connected through the ViTTS databus.

The ViTTS data bus is connected to a central database, at a secure main hosting site, where all sent messages are saved in data files. Through a Coordination, Evaluation and Report (CER) framework, overviews can be constructed automatically by extracting information from the database. These are then distributed over the data bus and presented to the authorised users.

The data transported over the ViTTS data bus consist of the following different elements:

- Major Trauma Outcome Study (MTOS+) data and triage data[7]
- Personal data
- Location data

Key for the system is early and unique identification of each victim. From the start of the process victims are marked with a unique identification number that is used in all registration systems of the disaster response chain. This allocated victim number (TGN) is similar to the number used in the barcode of the injury cards that are used for field triage. This is irrespective of a person's identity. When the identity of the victim becomes known later in the process, the TGN/barcode can be coupled to their Citizen Service Number, which is a unique personal ID number of every citizen who is registered in the population register (Municipal Personal Records Database) at the local government level. This can be done by simply adding the Citizen Service Number to the personal data. The Citizen Service Number is used by all government organisations.
To enter data in the field a Personal Digital Assistant (PDA) is used. The PDA is connected to the data bus through a local wireless network (WLAN) (*see Figure 2 and 3*).

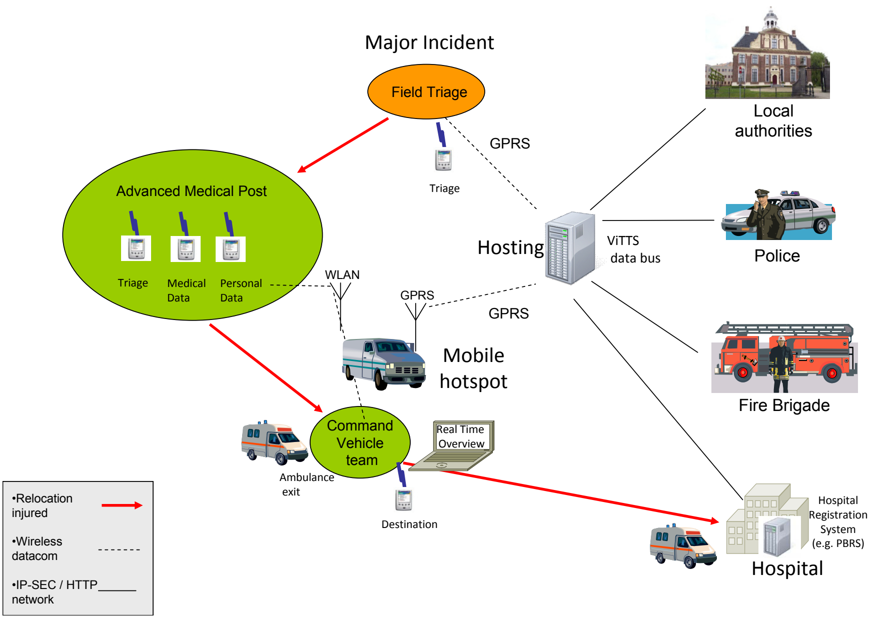

Figure 2. ViTTS @work: use during a disaster/Major Incident.

Figure 3. PDA reading of injury card

This WLAN is created by the first ambulance, which was equipped with a Mobile Access Router that establishes a secure, high-capacity data network. Links are maintained between the different wireless devices used in the field and the central database at the secure central hosting site. The PDAs have the capability to work offline, storing the data in the memory of the PDA, which can be transferred at a later stage whenever the LAN becomes available again. In the test version, transfer after network loss was an active step. During the test it never proved necessary because of the automatic handover of dataflow to a Tetra network during loss of WLAN and General Packet Radio Service GPRS coverage (loss of GPRS coverage was mimicked by deliberately switching of the modem, see below).

With the PDA, the barcode to register TGN and triage category can be read (*see Figure 3*). If the barcode scanner fails, manual entry of the TGN is possible; the number under the barcode represents the unique identification. Besides the barcode, triage data are stored in the central database real-time. If the condition of the patient changes and they are re-triaged to a different category, this is easily changed in the system. Retrieving entered data is as simple as scanning the barcode which will retrieve all data. Subsequently this data can be updated with additional data or a change of triage priority. Any additional information can be added to the ViTTS database at any time it becomes available or time permits.

The wireless network is formed by WLAN hotspots generated by the participating ambulances. A hotspot consists of a wireless access point (base station for IEEE 802.11b) and a mobile router (Cisco 3200 Mobile Access Router, Amsterdam). The PDAs have a wireless interface to communicate with the hotspots. If a router fails to generate a WLAN, the router from another ambulance can take over data traffic to guarantee system integrity.
Each hotspot has a gateway for several national mobile networks and is therefore connected to the central database through General Packet Radio Service (GPRS). If one of the mobile networks is not available or the wireless connection fails, automatic switching of dataflow to another network takes place. Furthermore, backup networks are in place for switching, including Terrestrial Trunked Radio (Tetra) networks that work on a different frequency to GSM. An example is the digital C2000 network, which is the current closed network for rescue-services in The Netherlands. It is available as one of the Tetra networks as a backup for the ViTTS and was tested to ensure switching occurred (see below). Altogether, there are currently three general categories of data-transport from the scene to minimize the chance of network failure: WLAN, GPRS and Tetra-networks, including C2000. Furthermore, the ViTTS can also be connected through wired Internet.
The data bus is connected to all critical emergency and hospital systems, either through GPRS or the regular wired Internet connections. Data are accessible via a series of access levels depending on the legal authorisation rights of the person accessing the database. The data can be accessed and completed by relevant parties in the rescue chain: ambulances, hospitals, fire department, police, Red Cross, the municipality and other agencies involved in the disaster (*see Figure 1*). Each have their own requirements and authorization. A security and authentication mechanism is built into the database to ensure patient privacy with all access to information logged. The 802.11-standards of the WLANs themselves do not offer encryption in their protocol, so information would travel "free readable". Therefore, data is encrypted with use of a key that is renewed automatically on a regular basis. Next to the encryption, access to different parts of information by the various organisations is warranted by the local authorities and secured by https and Virtual Private Network (VPN)tunnels.
For further description of the ViTT system and the processes of tracking and tracing the patient see Figure 2.

The ViTTS in practice

In case of a major incident, usage of ViTTS requires the following five steps:

1) Activation of ViTTS

When a major incident or disaster is identified, usually based on the initial report of the first ambulance arriving on the scene, the use of ViTTS is initiated by the ambulance dispatch centre. When the incident is first described a unique identification code is activated. Hospitals and ambulances are notified according to the ambulance assistance plan.

2) Triage and data gathering

The ambulance personnel arriving on site will initiate primary triage according to the Sieve principle.[1,8] The injury cards used during a disaster are developed according to the international Major Incident Medical Management and Support (MIMMS®) standards.[8] Apart from the international colour codes the cards contain a barcode with the unique TGN number.

The barcode is scanned by the PDA linked to a local network at the scene (*see Figure 3*). As soon as data are entered, they are available for all authorised services to view.

At the victims assembly point the evaluation teams gather and record additional data about each patient (secondary triage, additional medical data and if possible name and personal details; *see Figure 5a-c*).

3) Transport

The transport loading officer receives advice from the centralist regarding the allocation of patients to hospitals based on the victim distribution plan, supported by a ViTTS overview. When the ambulance leaves the disaster site, the designated hospital and transfer status of the victim will be entered by the loading officer (*see Figure 2*). During transport, the ambulance crew is able to access the central database enabling them to add and receive all available information and upload additional medical data in real-time.

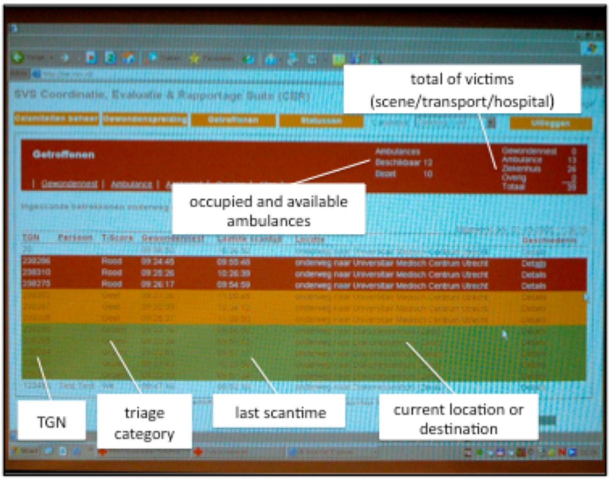

Figure 4. Real-Time overview of victims, their triage category and location (computer screenshot)

Figure 5. Screenshots of PDA: Registration personal data, Triage, Medical Data, Destination

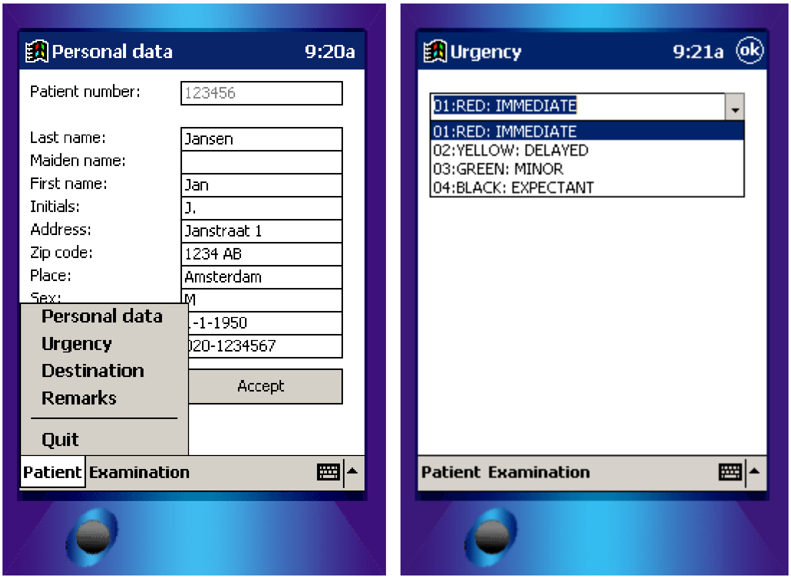

Figure 5a. Personal data and Triage (urgency)

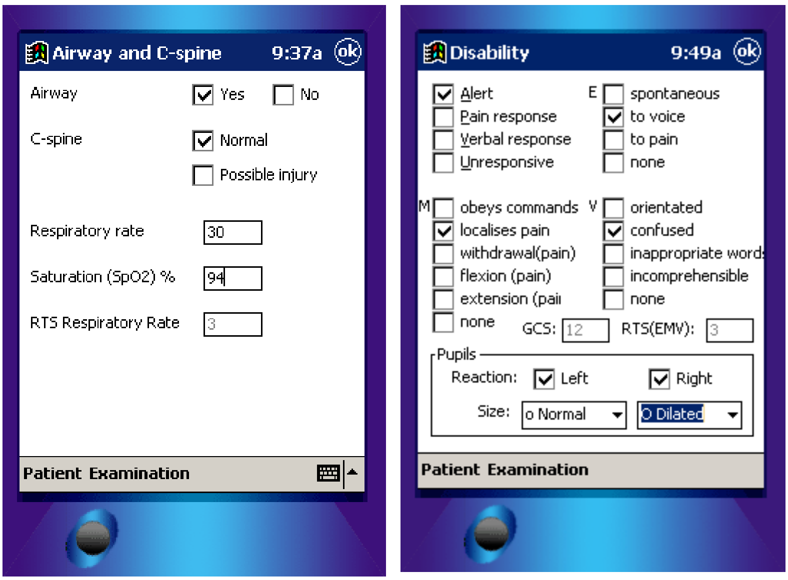

Figure 5b. Emergency care diagnostics examples

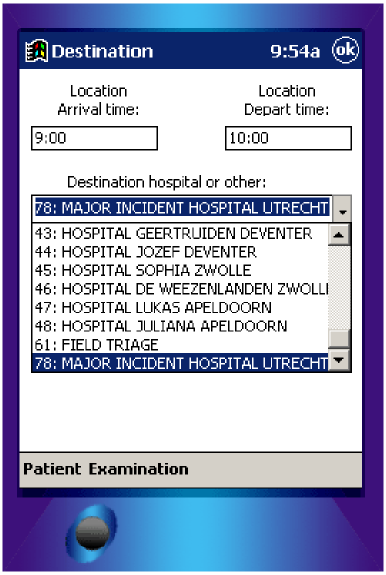

Figure 5c. Destination

The receiving hospital is automatically alerted to the pending arrival. In the emergency department an electronic overview is instantly created, describing the enroute patient(s) and providing a real-time overview of victims at the disaster site, awaiting transport and in the hospitals (*see Figure 4*). These overviews are automatically generated and are continuously updated.

4) Hospital arrival

Upon arrival the patient is handed over to the hospital's clinical staff and the barcode scanned again. The receiving hospital has access to the database by logging in through a secured Internet portal, enabling them to obtain all available patient data even before the patient is checked in. The subsequent treatment done in the hospital is uploaded to the central database using an Internet-connected infrastructure. The final patient discharge marks the end of the tracking and tracing process.

Throughout all the disaster relief actions, the information obtained about the patients is stored and updated in a centralised database via the ViTTS data bus.

5) Public information (Local government)

Parallel to the medical process, the local government is supplied with information concerning the number and location of victims via the ViTTS data bus. A security and authentication mechanism is built into the database to assure patient's privacy thus preventing access to all medical details of the victims. Family members can contact the authorities and can gain information about their affected relatives. In The Netherlands the Dutch Red Cross provides their Internet Registration and Information System (I-RIS) to all the municipalities.[9] This is a web-enabled application for registration of victims and relatives and family linking. Due to a commercially available component for the data transfer over the existing GPRS network, users can access I-RIS in the field, even when the fixed telecommunication network is affected. I-RIS can also be connected to the ViTTS data bus.

Testing for feasibility and usability

During the system development process, feasibility was tested in several stages. In 2002 and 2004 the first exercises were done using the ViTTS.

In the 2005 usability and robustness of the resulting system was tested in a realistic multidisciplinary scenario and evaluated by an independent qualified research institute, the Netherlands Organisation for Applied Scientific Research (TNO-ICT).

The test was performed in a simulation scenario involving a tanker truck with sulphuric acid that was driven into a building at some distance (400 meters) from the Major Incident Hospital (MIH).[10] Forty victims were involved, three ambulances each with 2 staff, a mobile medical team, doctors and nursing staff, the MIH as receiving hospital and pre-hospital personnel of the Utrecht municipality including the fire brigade and police. All ambulances were equipped with PDAs, injury cards and a Mobile Access Router to generate a local wireless network. The staff (ambulance, medical and administrative) had received a 1-hour instruction session about the ViTTS system and PDA–use before the simulation. Patients were triaged at the scene and subsequently transported to the MIH. On admission to the hospital they were re-triaged and registered. The TGN number from the barcode on the triage card can be coupled with an in-hospital registration number, thereby connecting ViTTS data with the in-hospital medical data. In this exercise this was done through the Patient Barcode Registration System (PBRS)[11,12] of the Major Incident hospital, but any hospital inpatient medical record system can be used.

All radio communication was scanned during the exercise and three observers from the research institute were present to follow the entire process. They performed time measurements in addition to the logbooks of the system itself. All logs for all data and XML-messages, with linked-time data to the electronic messages, were analysed afterwards by the research institute (TNO) in combination with their own time measurements.

Focus of evaluation was:

1. General functioning of the system
2. Accurate storage of all patient data
3. Adequacy of the wireless-system
4. On-time availability of data in the central database for the supporting departments. Maximum tolerated update time to the central database was set at 1 minute.
5. Reliability of the updates
6. Evaluation of the use of the injury cards and PDAs; initiating a triage priority, scanning of barcode/TGN, insertion of personal and medical data

Results

In the first tests, direct wireless connection between all components of the system, (PDAs, the wireless local area network, the wide area network) as well as integration with hospital electronic medical records were tested successfully. Information transfer proved accurate and simple, and it proved feasible to create accurate overview without interference of the user. These exercises resulted in some adaptations like automatic synchronization, automatic generation of overviews, and adaptation of the WLAN network.

Results from TNO evaluation of the exercise:

Conclusions TNO:

1. There were no observed system failures.
2. All patients were entered in the system at the pre-hospital incident scene. The patient data were accurately stored when entered in the system. On admission to the hospital not all ViTTS files were linked to the patient's in-hospital file, in this case the PBRS. This was due to human error; on admission, linking should be established by scanning the barcode from the ViTTS as well as the in-hospital registration number. It could also be inserted by hand if a barcode is not available for in-hospital patients.
3. The deployed local radio-network with hotspots, mobile routers and connection through GPRS to the central database worked well. Capacity problems did not arise during the trial. The hotspots were in each other's reception range, which generated reciprocal data exchange between the routers. There were no disturbances and the network load was low. In the switch over test the network switched to another

system (C2000) correctly when the GPRS-modem was switched off. Switching back to the GPRS when it became available again did not happen automatically; so for future use this requires adaptation of switching conduct of the routers.

4. Analysis of the log files for on-time availability of data revealed no time delays. Data were available in the central database within the stated time of 1 minute. An overview of patients at the incident scene and their triage category was available real-time at the receiving hospital (MIH), before the first patients arrived.
5. Data were updated in a timely fashion and also reliably. Information on the servers via the data bus was updated automatically. Average update time for the data bus was 500 milliseconds.
6. From the injury cards, only the barcode and the colour (triage) codes were consequently used during the exercise; other injury card functions were sparsely used. Due to unfamiliarity with the PDAs, some medical staff encountered some problems using them. This led to 2 disruptions in the use of PDAs that required technical assistance. It is was not clear if the fault was due to human or system error but both issues were resolved within 1 minute by switching the device off and on again. None of the entered data were lost and the devices functioned without any problems afterwards. In this exercise, the additional medical parameter options beyond primary triage of the PDA system, like RTS, were not often used.

Discussion

The essence of ViTTS is to promote interoperability between the different systems of all the participants in disaster relief. This is achieved through the data bus, providing a platform to connect all the different systems. This solution is consistent with the conclusions from the Report of the Advisory Board Coordination of Information and Communication Technology in Disasters commissioned by the Dutch Government in 2005.[13] The main bottleneck of information management during disasters is the availability and accessibility of correct and complete information. They concluded this cannot be solved by technical solutions alone but requires interoperability between the links in the chain.[13] The ViTTS data bus brings together the large diversity of currently non-compatible information systems and makes the information available and accessible, by all partners. It does not replace existing systems but merely connects them. The developed standards promote uniform information provision, which is necessary for good interoperability of the systems through the data bus. Furthermore, developing standards and predefining access to parts of the information in the data bus stimulated organisations and partners in the chain to define their information need and realise the value of information sharing and cooperation with partners. The ViTTS enables early, unique registration of victims/patients and triage in the field. Personal identification and additional details can be added at any time throughout the process. Online application and connection of the different systems used by all the different chains in disaster relief provides a real-time overview of the patient flow, visible to all disaster relief partners. This generates situational awareness; all cooperating services have access to real-time information of the victims (quantity, seriousness of injury), their whereabouts and destination. This information is necessary for an adequate coordination of the response and optimal deployment of resources. Ambulances and transport can be organised and coordinated according to need, and patients can be transferred to the hospital that has relevant capacity. Hospitals can adjust their capacity planning and level of preparedness according to the real-time overview from the disaster site. Furthermore, they can access the pre-hospital data of their arriving/expected patients, currently often missing.[14] Local authorities can reproduce information (for authorities, relatives and the media) more quickly and adequately. The Red Cross can use this information and can add data during the process searching for relatives. In this way the ViTTS contributes to the three pillars (situational awareness, resource allocation and stakeholder information) mandatory to coordinate a good disaster response. The urge to improve this information processing during a disaster, currently insufficient in The Netherlands, was again evident in the evaluation of a recent plane crash near Schiphol airport, where it took 4 days to locate the 136 victims[14,15] resulting in additional suffering for relatives.

The literature does not provide many research-based studies on victim tracing and tracking after disasters.[16,17] There is a limited number of reports from pilot tests performed in simulated emergency or disaster scenarios. Some systems describe intelligent triage tags that provide active location tracking[18-20] and/or embedded vital monitoring components.[21] The Wireless Internet Information Systems for Medical Response in Disasters (WIISARD, California) uses RFID tags and electronic intelligent patient monitoring devices tracking victim identification and location.[18,19]

In the Integrated Patient Tracking Initiative (IPTI) a group of experts in the United States joined together to develop a national framework that communities and regions can use when beginning their own patient-tracking programs. The first phase involved creation of national consensus requirements. Participants agreed on the following: platforms should be compatible and interoperable, the same device/system for day-to-day and mass-casualty type incidents should be used, the system must be flexible, data must be clinically based not research-based, devices and software must be configured to exchange data se-

curely and, finally, each incident record should automatically generate an identifying number.[22] The ViTTS complies well with these requirements.
The injury card that exists for national use in The Netherlands in case of disasters is already fitted with a barcode and works in the system. This card is developed according to the Major Incident Medical Management and Support (MIMMS®) system of triage and is derived from models that are current within NATO. MIMMS is adapted as the international standard of schooling for and approach to Major Incidents by NATO. Accuracy of the system could be further improved by refining the injury card barcodes as now they are not composed according to the international EAN-128 barcode system of the GS1-organisation.[23] Current TGNs on the barcodes can act as a unique patient number in a given disaster but are currently not composed as a barcode that necessarily represents a patient. By adding an application identifier (indicating the data type, in this case patient number, indicated by 8018), country code (87 for The Netherlands) and organisation code (this could be a general disaster relief code) the barcodes would all represent a truly unique patient numbering system (*see Figure 6*). The Application Identifier 8018 is an accepted international standard since 1995 for barcodes to indicate persons (and thus patients) and is also referred to as Service Relation Number (SRN). This discerns 'persons', from other barcodes that do not represent persons, for example household goods. Adding theses codes makes each number really unique and in accordance with the international EAN-128 barcode system of the GS1-organisation.[23]

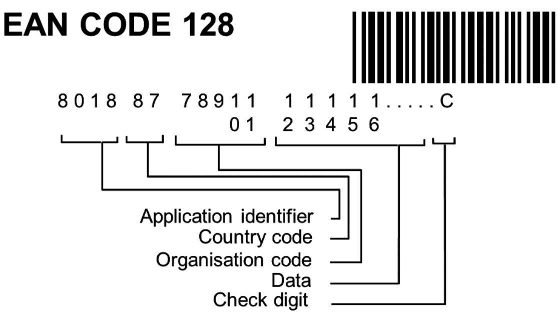

Figure 6. EAN-128 barcodes. Barcode according to the EAN-128 standard. The Application identifier indicates the type of data (e.g. 8018 stands for 'patient number'), country code is 87 for the Netherlands, the organisation code could be e.g. Disaster Relief Organisation

As the ViTTS data bus is not dependent on one system, ultimately the ViTTS could also be linked with RFID (Radio Frequency Identification), active[18] or passive. Currently, besides the advantages that RFID could have[24] e.g. active localization and less operator dependency, it still has drawbacks and obstacles for implementation. These concern reliability, privacy and security threats, and ongoing high costs of tags, RFID infrastructure and middleware. Maintenance costs remain unclear and there is a lack of interoperability, standards and tested best practices.[25]

At this stage, we chose to use the barcodes because of simplicity; the key to optimal disaster management.[26,27] The likelihood of problems with a process during a disaster increases as the similarity of medial disaster response activity to the corresponding day-to-day-care activity decreases.[28] The barcodes on the already existing triage cards in The Netherlands can be used. Furthermore, barcodes and barcode-scanners are already used daily in every Dutch hospital as well as in the public domain. The use of technology on a daily basis will enhance its use during a major incident or disaster. The hospital staff are accustomed to barcode use and there is no need for in hospital hardware adaptation to use the ViTTS. Barcodes have ease of use, speed, proven accuracy[11,12], low cost for the carrier and the hardware[25], easy maintenance and distribution of stock. Furthermore, it has a fall back option and manual readout when the scanner fails as the number under the barcode represents the unique identification. In this set up the barcode injury cards and the ViTTS combine simplicity with the advantage of electronically online registered data en dynamic use. Although the cards are simple paper tags, by scanning them and using them as triage tags in an online system many earlier encountered disadvantages with paper tag systems[16,19] are resolved; the space for information is no longer limited and they become dynamic. Triage codes can be changed, scanning at transport points and the hospital ED provides tracking information and data can be complied in different stages and from different providers. By using the ViTTS, the triage cards no longer stand alone but are connected to the systems of the participants in the disaster management and have the functional advantages of electronically recorded and online data.

Study limitations

The evaluation by TNO shows that the online ViTTS works and provides on-time availability of data in the central database available for partners in the municipal and medical process. The most significant limitation of the exercise is the relative low number of victims. Nevertheless, with the use of only 3 PDAs this incident was mastered. To guarantee scalability the system does not solely depend on GPRS. As this can be overloaded in disaster situations, communication in the mobile domain is supported WLAN created by Mobile Access Routers in

the ambulances. If this fails, Tetra networks provide a robust backup system that is not accessible to the public.
Spoken data currently have priority in a GPRS network and they will almost always cause an overload of the network during a disaster. Quality of Service terms (agreements regarding guarantee of connection quality and priority on the network) with the network providers are necessary to give priority to ViTTS data in order to prevent blocking of the gateways to the GPRS network. Apart from public networks, it is important to have a backup system that can take over the dataflow if the GPRS system is flooded and priority agreements fail. In The Netherlands some closed networks like C2000 and Tetra are available for switch over of the dataflow. We successfully tested this automatic backup in the exercise. In the switching test the network switched to C2000 correctly when the GPRS-modem was switched off. Switching back to GPRS when it became available again did not go automatically, so this needs adaptation of switching conduct of the routers.
To protect the usability of the ViTTS system in case of an incident that would destroy the earthly mobile network, an extra satellite gateway could be added, making the system more robust, providing another fall back for data transfer. Currently we did not choose satellite connection as the primary mode as it would be possible for outdoor use but has its limitations for indoor use with GPS data traffic.
A weak point of the evaluated exercise was the linking of pre-hospital data to in-hospital data; on admission to the hospital not all barcodes were scanned simultaneously and therefore not all ViTTS data were linked to the in-hospital PBRS data. This can be corrected at any other location of care, e.g. in the treatment area or on the ward. More frequent use of the system will probably resolve this as people get used to doing this at check in. A warning could easily be built into the receiving hospital system whenever you want to admit a patient to the hospital and scanning the barcode injury card has been omitted. This check could also be used in different stages of the process e.g. the ambulance, when you open a new transport form or upon admission to the ward. The same accounts for asking patients for personal data. It has been argued that if you provide a patient with a number the necessity for the medical personnel to obtain his personal data diminishes. The system could issue a reminder for this at each stage.

Conclusions

The essence of ViTTS is to promote interoperability and to start unique registration and triage of victims close to the incident or disaster site, while personal identification and further medical details can be added later in the management process. ViTTS can help prevent unnecessary additional suffering caused by lack of patient information and patient location resulting in inefficient use of medical resources and uncertainty among relatives. Online application and connection of the different systems used by the different organisations in disaster management makes real-time overview of victim flow (quantity, seriousness of injury, location) visible to all involved disaster relief partners. The current systems that now function as islands can remain in place and are merely connected through the ViTTS data bus. Therefore, the ViTTS provides early management information to the chain of command necessary for an adequate disaster response with optimized resource allocation (cost- and care effective) and avoidance of unnecessary public distress.

Acknowledgements

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Chapter 5

Wound infections in repatriated survivors of the tsunami disaster

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Wounds 2006; 18(4):92-100

Abstract

The tsunami of December 26, 2004, had an enormous death toll, and during the aftermath, numerous victims developed severe wound infections. The initial stream of victims was tremendous and had to be managed under extraordinary circumstances, often with too few staff, surgical equipment and antibiotics, which posed challenges to the treatment of wounds. Wounds were often empirically treated with antibiotics without the support of culture results. The medical literature, Internet, and lay press carried reports of patients being at risk of deadly fungal infections and infections caused by waterborne and highly resistant pathogens. In most cases, these reports concerned only 1 or 2 repatriated travelers. The authors analyzed wound infections, culture results, and resistance patterns seen in 23 repatriated tsunami victims. Wound cultures showed a spectrum of pathogens different from those usually encountered in European hospitals. A combination of waterborne bacteria and a high prevalence of gram-negative bacteria and enteric commensals were found in wound and surveillance cultures. Most wound infections were polymicrobial, and bacteria were often multi-drug resistant. These results might influence the choice of empirical antibiotic treatment as adjunct to the surgical treatment of wound infections in tsunami or future flood victims. In such situations, strict quarantine of repatriated patients with appropriate microbiological assessment on admission is important.

Introduction

On December 26, 2004, a strong earthquake off the west coast of northern Sumatra triggered a devastating tsunami that hit 8 countries in south Asia, southeast Asia, and east Africa. The tsunami disaster caused more than 280,000 victims, and many of the survivors subsequently died from infection. Measles, diarrhea, viral hepatitis, acute respiratory infections, malaria, and malnutrition are the main causes of death in complex emergencies.[1,2] Usually, epidemics of other infectious diseases are expected,[1,2] but in this case, only a few cases (clusters) of various communicable diseases were reported, and no major outbreaks were reported.[3] Patients who survived the disaster were often severely injured, and the incidence of wound infections was high.[4,5] Several reports appeared in the medical literature, on the Internet, and in the lay press of patients being at risk of deadly fungal infections and infections caused by waterborne and highly resistant pathogens.[6–8] These reports were based on 1 or 2 repatriated patients and raw data from the Thai Ministry of Public Health regarding the results of cultures taken from 33 patients in Phuket during a surveillance program.[9] A report on a group of 17 victims repatriated to Germany and a recent article about a large retrospective survey in Thailand provided more detailed information on culture results and resistance patterns in larger groups of tsunami victims.[8,10]
In the Netherlands, a Major Incident Hospital was established in the early 1990s during the first Gulf War. The facility is also used as a quarantine unit for repatriated groups of injured Dutch patients as well as a first response unit for (pan) epidemic outbreaks of infectious diseases. On January 1, 2005, 5 days after the tsunami disaster, 23 Dutch tsunami victims were admitted to this hospital. In this report, the authors describe the wound infections, causative organisms, and resistance patterns found in these patients with 6- to 8-month clinical follow-up.

Patients and Methods

On January 1, 2005, 5 days after the tsunami disaster, 23 Dutch tsunami victims were collectively repatriated from 7 hospitals in Bangkok and Phuket, Thailand. They were admitted to the Major Incident Hospital in Utrecht for evaluation and further treatment.
On admission, all wounds and other injuries were systematically reviewed and documented along with previously received treatment. Superficial wounds were defined as wounds that did not involve or penetrate the muscular fascia and therefore involved strictly skin and subcutaneous tissue. Deep wounds were defined as wounds that penetrated these barriers. Diagnosis of clinical wound infection was judged by a physician based on the presence of 1 or more

signs, such as pus, foul smell, necrosis, gangrene/subcutaneous emphysema, cellulitis, erythema, swelling or infiltration of adjacent tissue, pain, and delayed healing. Three sets of culture swabs were taken from all wounds and 3 sets of surveillance cultures were taken from the pharynx, perineum, and nose; 1 rectal swab was taken. Urine, blood, or sputum samples were taken only when indicated. Specimens were cultured and tested for antimicrobial susceptibility according to 2003 National Committee Clinical Laboratory Standards (NCCLS)[11,12] using an automated method for bacterial identification (PHOENIX™ Automated Microbiology System, BD Diagnostics, Franklin Lakes, NJ). In some patients, additional E-tests were performed to confirm antibiotic resistance, especially to aminoglycosides. Cultured microorganisms and resistance patterns were evaluated in relation to the clinical picture, current as well as previous antibiotic treatment, and coexisting conditions.

The repatriated patients were treated in quarantine to prevent transmission of multi-resistant microorganisms (eg, methicillin-resistant *Staphylococcus aureus,* MRSA), if present, to other patients or healthcare workers. All treatments, including surgical procedures, was performed in separate facilities within the Major Incident Hospital.

Results

Fourteen men and 9 women with a mean age of 41 years (range 16–64) were admitted. Five patients had relevant comorbidity or preexisting conditions, namely, diabetes, pregnancy, cystic fibrosis, use of prednisone, and atrophy of the injured limb due to a congenital pes varus (clubfoot).

Wounds, other diagnoses, and treatment prescribed in Thailand are summarized in *Table 1*. Nearly all patients had superficial lacerations and cuts/scratches, predominantly on the extremities. Nineteen patients had also sustained more extensive wounds of the skin and subcutis (18 patients) and/or deep injuries penetrating the fascia (13 patients). Clinically, 13 patients had clearly infected wounds on admission. Nine patients had already undergone surgical debridement in Thailand. In 4 additional patients, wounds had been opened after suturing (2 patients) or superficially debrided on the ward (3 patients). Eight patients needed further surgical wound debridement in the hospital, 2 of whom had not been operated on in Thailand.

Table 1. Patient characteristics: wounds, other diagnoses and previous treatment on admission, 5 days after the tsunami disaster (n=23)

Wounds	Superficial lacerations/cuts		22
	Wounds of skin and subcutis		18
	Wounds deeper than fascia		13
	Clinical wound infection in Thailand		16
	Antibiotics for wound infection in Thailand		16
	Surgical debridement in Thailand		9
	Clinical wound infection present on admission in the authors' center		13
	Total of patients with wound infection (resolved or present)		17
Locomotor	Traumatic rupture of tendon		2
	Fractures	closed	4 (*)
		open	1 (*)
	Traumatic amputation of finger		1
	Shoulder luxation		1
Pulmonary	Pneumonia		2 (†)
Gastro-enterologic	Diarrhea		1
Other	Commotio cerebri		1

(*) In one case fracture was sustained during a car accident on the day prior to the tsunami.
(†) One case occurred in a patient with cystic fibrosis. Antibiotic treatment was initiated before the tsunami disaster, but symptoms were aggravated by the humid environment.

Nineteen of the 23 repatriated patients had been treated in Thailand with antibiotics for 2 to 5 days for aspiration pneumonia (n = 2), open femur fracture (n = 1), and wound infections (n = 16). In 8 of these patients, antibiotic treatment could be discontinued on admission in the Netherlands. The results of the wound cultures are presented in *Tables 2 and 3*. Ten patients had no positive wound cultures. Cultures for the other 13 patients revealed bacteria and resistance patterns that differed from those usually found in wound infections in the Netherlands.[13] Most cultures were polymicrobial. Gram-negative and water-borne bacteria dominated the spectrum. Few cultures were positive for *Staphylococcus aureus*, especially those from patients treated with either oxacillin or clindamycin in Thailand. Only 1 patient still had S aureus-positive cultures, and 1 other patient appeared to have methicillin-resistant S aureus (MRSA).

The MRSA surveillance cultures initially detected 1 patient whose nasal culture was MRSA positive. One patient was negative for MRSA in the 3-fold inventory cultures but became MRSA positive 3 days later after her antibiotic treatment was terminated. Although both patients were repatriated from the same Thai hospital, they were infected with different strains of *S aureus*. Rectal swabs revealed several multi-drug-resistant gram-negative bacteria that differed in their resistance to those detected in the Dutch surveillance inventory (SWAB),[13] such as multi-drug-resistant E coli, Achromobacter species, Acinetobacter species, and Proteus species (*Table 3*). The resistance of E coli

Table 2. Wound infections, antibiotics used in Thailand and culture results

Patient	Wounds on admission in the Netherlands	Antibiotics received in Thailand	Organisms cultured in wound on admission
1	Deep infected leg wound with Achilles tendon rupture	OXA, CFT	Bacillus cereus, Acinetobacter calcoaetius-baumanni
2	Toe wound	OXA, CTX, MEZ	None
3	Deep infected leg wound with exposure of tibia	OXA, GEN, MEZ, AUG	S. aureus, Aeromonas hydrophila/caviae, Achromobacter species, Aeromonas veronii biovar
4	Deep infected arm wound with transsection of biceps and arterial bleeding	CLI, CTX	None
5	Infected arm and leg wounds	OXA, CTX	None
6	Infected wound right leg wound, multiple superficial wounds	AUG, MOX	Proteus mirabilis, Pseudomonas aeruginosa, Providentia stuartii, E. coli
7	Infected deep leg wounds	CLI	Pseudomonas aeruginosa, Morganella morganii, Klebsiella pneumoniae, E. coli
8	Traumatic amputation dig IV, lacerations	None	None
9	None apart from abrasions	None	None
10	Infected leg wounds, hand wounds	CLI	None
11	Deep leg and arm wounds, resolved cellulites	AUG	E. coli
12	Infected ankle wound	AUG	Enterobacter cloacae, Pseudomonas aeruginosa, Shewanella putrefaciens, E. coli
13	Infected ankle wound with erysipelas	AUG	Aeromonas veronii biovar veronii, Providencia sturtii, Proteus mirabilis, E. coli
14	Infected deep leg wounds	VAN	E. coli, methicillin-resistant Staphylococcus aureus
15	Wound hallux (previously infected)	AUG, PEN	E. coli, Proteus mirabilis
16	No wounds	CIP, AZI	none
17	Aspiration pneumonia	CLI, AMI, LEV,VAN, IMP	Methicillin-resistant Staphylocoocus aureus, E. coli
18	Infected deep lower leg wounds	CEF, GEN, AUG	Porteus vulgaris, Escherichia coli, Pseudomonas aeruginosa

Table 2. Continued

Patient	Wounds on admission in the Netherlands	Antibiotics received in Thailand	Organisms cultured in wound on admission
19	Infected foot hematoma with tendon rupture, head and pelvis wounds	CIP	E. coli, Klebsiella pneumoniae, Salmonella mgulani, Aeromonas species
20	Deep arm wound, wounds of all extremities, head and back	PEN, CTX	None
21	Pretibial wound	None	E. coli
22	Heel wound	None	None
23	Open fracture femur, thigh wound	CEF, CIP	None

Note that 2 patients (4 and 11) were diagnosed with clinical wound infection and had negative cultures or cultures with only one organism. All other patients with clinical wound infection appeared to have polymicrobial infections. Of course, cultures taken 5 days after the tsunami were influenced by antibiotic and surgical treatment in Thailand. The following antibiotics were used in Thailand: AMI (amikacin), AUG (amoxicillin-clavulanate), AZI (azithromycin), CEF (cefazolin), CFT (ceftazidim), CTX (ceftriaxon), CIP (ciprofloxacin), CLI (clindamycin), GEN (gentamicin), IMP (imipenem), LEV (levofloxacin), MEZ (metronidazol), MOX (moxifloxacin), OXA (β-lactamase resistant penicillin, such as oxacillin or flucloxacillin), VAN (vancomycin).

Table 3. Resistance of microorganisms in wounds and inventory cultures

Micro-organism	Benzylpenicillin	Oxacillin/flucloxacillin	Amoxicillin/ampicillin	Amoxicillin + clavulanate	Piperacillin +tazobactam	2nd generation cephalosporin	3rd generation cephalosporin	4th generation cephalosporin
WOUNDS								
Gram-positive cocci								
Staphylococcus aureus	5/5	0/5	5/5	0/5	0/5	0/5	0/5	5/5
Gram-negative rods								
Aeromonas hydrophila/caviae			3/3	2/3		0/3	0/3	
Aeromonas veronii biovar sobria			1/1	1/1	0/1	1/1	0/1	0/1
Aeromonas veronii biovar veronii			1/1	0/1	0/1	1/1	0/1	0/1
Aeromonas spp			1/1	1/1	0/1	1/1	0/1	1/1
Escherichia coli			1/3	0/3	0/3	0/3	0/3	0/3
Klebsiella pneumoniae			2/3	2/3	0/3	0/3	0/3	0/3
Morganella morganii			1/1	1/1	0/1	1/1	0/1	0/1
Proteus mirabilis			2/3	0/3	0/3	0/3	0/3	0/3
Providencia stuartii			3/3	3/3	0/3	3/3	0/3	0/3
Pseudomonas aeruginosa			5/5	5/5	0/5	1/5	3/5	0/5
Salmonella mgulani			0/1	0/1	0/1	0/1	0/1	0/1
Shewanella putrefaciens			0/1	1/1	0/1	1/1	0/1	0/1
Anaerobes								
Bacillus cereus	1/1	1/1						
INVENTORY								
Gram positive cocci								
Staphylococcus aureus	5/5	0/5	5/5	0/5	0/5	0/5	0/5	5/5
Methicillin-resistant Staphylococcus aureus	3/3	3/3	3/3	3/3		3/3	3/3	3/3
Gram negative rods								
Achromobacter species					0/1			1/1
Acinetobacter calcoacetius-baumanni			1/1	1/1	1/1	1/1	1/1	1/1
Enterobacter cloacae			2/2	2/2	0/2	2/2	0/2	0/2
Escherichia coli			10/17	7/17	4/17	7/17	5/17	
Proteus vulgaris			1/1	0/1	0/1	0/1	0/1	0/1

Numbers of resistant microorganisms in relation to the total number of cultured strains. For example, 5 out of 5 cultured Staphyloccus aureus strains were resistant to benzylpenicillin (denoted as 5/5) and none of these five strains was resistant to oxacillin/flucloxacillin (denoted as 0/5). Examples of tested antibiotics are given in parentheses.

Table 3. Continued

Micro-organism	Carbapenem (meropenem)	Aminoglycosides (gemtmicin)	Fluoroquinolon (ciprofloxacin)	Macrolid	Lincomycin (clindamycin)	Glycopeptides (vancomycin)	Tetracyclin	Linezolid	Cotrimoxazol	Colistin
WOUNDS										
Gram-positive cocci										
Staphylococcus aureus	0/5	0/5	0/5		0/5	0/5	0/5	0/5	0/5	
Gram-negative rods										
Aeromonas hydrophila/caviae		0/3	0/3				0/3		0/3	0/3
Aeromonas veronii biovar sobria	0/1	0/1	0/1				0/1		0/1	0/1
Aeromonas veronii biovar veronii	0/1	0/1	0/1				0/1		0/1	0/1
Aeromonas spp	0/1	0/1	1/1				1/1		0/1	0/1
Escherichia coli	0/3	1/3	1/3				1/3		0/3	0/3
Klebsiella pneumoniae	0/3	0/3	1/3				0/3		0/3	0/3
Morganella morganii	0/1	0/1	1/1				1/1		1/1	1/1
Proteus mirabilis	0/3	1/3	1/3				3/3		1/3	3/3
Providencia stuartii	0/3	0/3	2/3				3/3		0/3	3/3
Pseudomonas aeruginosa	0/5	0/5	0/5				5/5		5/5	0/5
Salmonella mgulani	0/1	0/1	0/1				0/1		0/1	0/1
Shewanella putrefaciens	0/1	0/1	0/1				0/1		0/1	0/1
Anaerobes										
Bacillus cereus					0/1	0/1	1/1		0/1	
INVENTORY										
Gram positive cocci										
Staphylococcus aureus	0/5	0/5	0/5		0/5	0/5	0/5	0/5	0/5	
Methicillin-resistant Staphylococcus aureus	3/3	0/3	3/3	3/3	3/3	0/3	0/3	0/3	0/3	
Gram negative rods										
Achromobacter species	0/1	1/1	1/1							
Acinetobacter calcoacetius-baumanni	0/1	1/1	1/1				1/1		1/1	0/1
Enterobacter cloacae	0/2	1/2	0/2				1/2		1/2	0/2
Escherichia coli	1/17	12/17	12/17				12/17		11/17	0/17
Proteus vulgaris	0/1	1/1	0/1				1/1		1/1	1/1

to aminoglycosides in the inventory cultures was higher than expected, with mean E-test values for gentamicin of 256 mg/L (range 16–1024 mg/L) and tobramycin 64 mg/L (range 0.25–256 mg/L).
After 5 days, 17 patients were discharged home, and the remaining 6 patients were transferred to other facilities (1 nursing home and 5 hospitals) where they were kept in quarantine during the processing of culture results in order to clear the Major Incident Hospital. During this time, no complications were observed in the patients. All responded well to treatment, and the wound infections had not deteriorated. Fifteen patients attended a follow-up assessment 6–8 months later. By this time, all wounds had healed, although some slowly. No adverse events were reported.

Discussion

In this report, the authors described the wounds, wound infections, and microbiological pattern of wound cultures of repatriated Dutch tsunami victims. The main findings were that the wounds of the tsunami victims were infected with polymicrobial, multi-drug-resistant gram-negative microorganisms different from those typically found in infected wounds in the Netherlands (*Tables 2 and 3*). The pattern of pathogens probably reflects how the injuries were caused, the difficulty in providing optimal wound care under the extraordinary circumstances, and the selection of microorganisms as a result of antibiotic usage.
The etiology of the injuries is different from that of the average non-tsunami trauma patient. Most tsunami victims were injured by debris and polluted seawater, which contributed to wound contamination and further tissue damage. Bacteria, such as Pseudomonas, Aeromonas, and Shewanella, were probably washed into wounds. Of note, no infections caused by Vibrio or Burkholderia species were encountered.[6,14–19] The large number of enteric pathogens detected suggests either surface contamination by seawater or true polymicrobial infection.
Aeromonas hydrophila is present in salt, brackish, and fresh water and has previously been reported to cause rapidly progressing wound infections.[20] In a Thai surveillance program, Aeromonas hydrophila was recovered in 2 of 33 patients.[9] In the retrospective large series conducted in southern Thailand, Aeromonas species were the most commonly detected bacteria and were isolated from 22% of the patients.[10] In the authors' group, 3 of 23 patients tested positive for Aeromonas species. One patient with Aeromonas hydrophila had a clinically evident wound infection on admission 5 days after the tsunami despite prior

surgical debridement and antibiotic therapy. Repeated surgical debridement and antibiotic treatment finally resulted in complete wound healing by secondary intention.

Shewanella putrefaciens can be found in seawater, fresh water, fish, and soil. It is not usually found in human wounds, although incidental case reports have been published.[16] Shewanella putrefaciens was not cultured in the survey in Thailand,[10] but the pathogen was cultured from a patient with an infected heel wound in the present study. This patient had initially been treated with amoxicillin-clavulanate, to which this strain was sensitive, but the wound had been sutured in Thailand after initial cleaning. The wound was opened and surgical debridement was performed in the airplane, and subsequent open-wound treatment without antibiotic support at the authors' center cleared the infection. This emphasizes the need for adequate surgical treatment and the relatively adjuvant role of antibiotics in treatment of infected wounds.

Aside from the environmental factors present at the time of injury, surgical wound management plays a key role in the development of wound infections. The results of the authors' cultures, taken on admission in the Netherlands, are definitely influenced by prior surgical and antibiotic treatment. The initial flood of victims was enormous and had to be managed under extraordinary circumstances with too few staff and insufficient surgical equipment and antibiotics,[4,5,9,21,22] which posed challenges to early medical treatment. Survivors mainly suffered from aspiration or trauma (eg, wounds, fractures, head injuries), and many needed surgical treatment. Occasionally, wounds were sutured despite contamination. Many patients rapidly developed foul-smelling wounds with frank pus, and surgical treatment may have been suboptimal under these harsh conditions.[4,5,9,21,22] Empirical antibiotic treatment was given without knowledge of the infecting species or antibiotic resistance, and availability may have played a role in the selection of the antibiotics that were used. A recent article discussed the pathogens expected in infected wounds according to the type of exposure and proposed a framework for choosing empiric antibiotics.[23] However, the wounds of the patients in the present study were of mixed etiology and exposure. Skin contamination as well as exposure to seawater, fresh water, and soil played a role.

Although S aureus is the most common microorganism that causes wound infections,[24] relatively few patients in the present study were infected with this pathogen. This could be because most patients had already been treated with oxacillin or clindamycin prior to admission to the Major Incident Hospital, and therefore, selection of remaining microorganisms might have occurred. Patients treated with a third-generation cephalosporin had fewer wound infections, but because there were few patients, this observation should be interpreted with caution. Empirical treatment with a third- or fourth-generation cephalosporin, such as carbapenem or piperacillin with tazobactam, appears to be the preferred treatment, as most microorganisms collected from wound swabs were sensitive to these antibiotics (*Table 3*). However, these results might be influenced by previous treatment, as some pathogens would have been selected by the previous antibiotic treatment in Thailand. On the basis of the culture results, treatment with only beta-lactam antibiotics, second-generation cephalosporins, and fluoroquinolones appears to be inadequate. Third-generation cephalosporins are effective against most of the pathogens isolated except Pseudomonas species, whereas fourth-generation cephalosporins are not effective against some gram-positive pathogens, such as S aureus, which still is an important causative agent in normal wound infections. Carbapenem and piperacillin with tazobactam appeared to be effective against most causative pathogens and would be sufficient for empirical treatment.

Most wounds were infected by several pathogens. Given the large number of enteric pathogens isolated, it is difficult to say whether this reflects surface contamination by tsunami water or true polymicrobial infection. Polymicrobial infections are frequently seen in traumatic injuries of different causes.[25,26] Because of the synergistic nature and necrotizing tendency, polymicrobial wound infections tend to be severe.[24] Indeed, all patients infected with multiple pathogens had infected wounds on their arrival in the Netherlands. The authors' observation of polymicrobial infections is consistent with the Thai results, where 72% of the wound infections were polymicrobial.[9,10] However, in these studies, no surveillance cultures were done, so the relation to clinical wound infection is not clear.

The authors of the present study also found that gram-negative bacteria had different resistance patterns from those usually observed in the Netherlands.[13] Additionally, the cultures from rectal swabs revealed several multi-drug-resistant gram-negative bacteria that differed in their resistance from those of the Dutch surveillance inventory, such as multi-resistant E coli, Achromobacter species, Acinetobacter species, and Proteus species. This might reflect colonization by local Thai bacteria, influenced by local antibiotic policies. However, many of these isolated organisms are innately resistant to antibiotics when isolated from their natural environment. This may occur partly because some of the molecules that are in antibiotics also occur in nature. Therefore, resistance patterns cannot be attributed to antibiotic use only.

In general, approximately 18.2% of all patients repatriated to the Netherlands were shown to be carriers of drug-resistant microorganisms.[27] Travel from Asia is a risk factor for carrier-state of resistant gram-negative pathogens. Additionally, the antibiotics given to these patients may, in part, have caused this resistance.

However, a previous Dutch analysis showed that the country from which a patient is repatriated is more significant than the antimicrobial treatment received by the individual patient in a foreign hospital for the acquisition of multi-drug-resistant gram-negative microorganisms.[27] The observation that a patient who initially tested MRSA negative and subsequently became MRSA positive after stopping vancomycin treatment may have consequences for MRSA quarantine policy in repatriated patients. In the Netherlands, the incidence of MRSA is low (< 1%) whereas approximately 4.7% of patients repatriated to a Dutch hospital are carriers of MRSA.[27]

Conclusion

Wound infections in tsunami victims show a different spectrum of pathogens from what is normally encountered. A combination of aerobic-anaerobic and waterborne bacteria and a high prevalence of gram-negative bacteria and enteric commensals should be anticipated. In the present study, most wound infections were polymicrobial, and bacteria were often multi-drug resistant. This should be anticipated when starting empirical antibiotic treatment and stresses the importance of strict quarantine and appropriate microbiological assessment on admission of such patients.

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Chapter 6

Disaster-related injuries and quality of life; a five year prospective follow-up in a non-residential sample after the 2004 tsunami

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Submitted

Abstract

Background

Disasters impact physical and mental health. Most evidence comes from cross-sectional, short-term studies on mental health alone. Long-term studies on both physical and psychological health combined and quality of life are scarce.

Patients and methods

Prospective 5-year follow-up study on physical and psychological/emotional impact and quality of life (EuroQol-5D+) in wounded repatriated Dutch tsunami victims.

Results

Quality of life scores at 6 months and 5 years were non-significantly lower than a reference population. However, a third at 6 months and a quarter at 5 years rated their health worse than pre disaster. Use of health care for trauma related complaints was 68% at 6 months and 26 % at 5 years. One third still felt hindered in their daily activities after 5 years. No demographic, injury or psychological exposure characteristics could be related to quality of life outcomes except age and educational level, and ISS on the short term.

Conclusions

Tsunami exposure with concomitant injury had considerable middle and long-term physical and emotional impact. Impact on daily activities and high health care use was not reflected in lowered quality of life scores. Moreover, some disaster-related effects may not emerge until years post-disaster. This asks for long-term and multidisciplinary attention.

Introduction

The earthquake that led to massive tsunami waves that hit the South East Asian coastline on the morning of December 26, 2004 affected tens of thousands of people in the region. The waves took the lives of local citizens, as well as tourists that were in the area. Many experienced a life-threatening situation or became wounded. Airlifts were organized to repatriate wounded tourists back to their home countries. This was also the case for a group of Dutch people. Not much is known about the impact of physical injury in a mass disaster like the tsunami, or on the long-term overall wellbeing of this particular population. Most studies concern cross-sectional or short term studies and focus on mental health only.[1] Some data on longer-term impact of experiencing such a disaster concern the indigenous population[2, 3], which is not comparable to a non-resident group. While the non-resident group can return to a intact home and society, the local population resided in a devastated environment with social circumstances that, in addition to the experience itself, further affected their quality of life.[4] A few recent studies evaluated the psychological impact of the tsunami on tourists from Switzerland and Sweden.[5-8] They report the outcome of a single retrospective measurement of posttraumatic stress disorder (PTSD) symptoms at 6 months[5], 14 month[8] and in one study to maximum 2 and a half years.[7] PTSD symptoms may be self-limiting but may also persist for many years and may change over time.[9] Many health problems, physical as well as psychological, may arise immediately after a disaster. They may persist for years, and there is also evidence that some disaster related effects however may not emerge until a year or more after the event.[10]

Little information is available on the impact of experiencing a natural disaster like the tsunami alone on (health related) quality of life in an injured population. Data on the impact on both physical and psychological health combined in health-related quality of life are scarce.[12] Studies after the World Trade Centre Disaster showed that physical and mental health problems are substantial even after years.[13] Others suggest that disaster exposure did not have a lasting impact on variation in physical wellbeing.[14] Physical and psychological pathology can co-occur though after disasters and large scale trauma; patients with psychopathology are more likely to become physically ill[15] and people with physical injury due to the disaster seem to be more likely to develop psychological problems like PTSD or depression.[9]

The objective of the present study is to follow-up on the physical and psychological/emotional impact of exposure to a natural disaster in a non-residential group of wounded Dutch subjects. Approximately 500 Dutch persons worked or celebrated their holidays in the affected region at the time the tsunami hit the shore. On January 1st, 5 days after the tsunami disaster, a group of wounded

Dutch patients was collectively repatriated from Bangkok and Phuket (Thailand). They were admitted to the Major Incident Hospital (MIH) in Utrecht for further evaluation and treatment. In an earlier study we reported on the wounds and infections in this sample.[16] For this study we prospectively followed-up on the middle long (6 months) and long-term (5 years) effects on health related quality of life, impact only daily activities and the use of healthcare facilities.

Patients and Methods

The sample we studied is derived from the group of 23 Dutch patients that were all collectively repatriated from different hospitals in Bangkok and Pukhet to the Major Incident Hospital (MIH) in the Netherlands. Nineteen patients of this wounded group consented to participate in a prospective follow up study on physical and psychological/emotional impact of the tsunami. Four patients did not wish to participate.
The MIH is an institution solely dedicated to delivering immediate care to multiple casualties under exceptional circumstances.[17] The repatriated patients were treated in group quarantine to prevent transmission of eventual multi-resistant microorganisms to other patients or health care workers. All treatment, including surgical procedures, was performed in separate facilities within the MIH. Psychosocial support was available from the beginning by mental health workers and trough trained nursing staff. The Institutional Review Board of the University Medical Centre Utrecht and the MIH approved the study after an expedited review. All included patients gave written informed consent.

Patients

A total of eleven males and eight females were included in the study. The median age was 38 years (range 26-64). The 4 patients that were admitted but did not consent to participate did not differ significantly in age and gender, ISS or exposure from the rest of the group. With regard to psychological trauma, three of them had been directly exposed to the tsunami and one of them sustained injuries actually a day prior to the tsunami, due to an accident. All patients were staying in the area to celebrate their holidays.
Twelve of the 19 patients had received a college or university degree. The majority (18/19) was working. Eighteen patients were married or living together with a partner. Medical history revealed diabetes with oral medication (1), clubfoot (1), arteriitis temporalis treated with prednisone (1), familiarly clotting disorder treated with coumarine derivates (1) and a history of kidney surgery (1). One of the patients was in the first trimester of pregnancy. Psychological screen showed a history of previous burn out syndrome (1), PTSD (1) and history of depression (1).

Measurements on admission

All patients were transported with medical supervision from Pukhet and Bangkok to the Netherlands on January 1st, 2005. They arrived at night on the airport after a direct long distance flight from Thailand. They were transported by ambulances to the hospital and arrived in the MIH around 4 am New Years Eve. A team of 5 doctors and 12 nurses were prepared to receive and assess the group. Upon arrival all patients were registered with the Patient Barcode Registration System securing quick and accurate overview of patients and their injuries.[18] On admission, interviews, physical examinations, cultures and blood tests were performed. Sociodemographic details (age, gender, household composition, educational level, employment status), medical and mental health status and history were systematically documented along with details of the experience and situational information.

Physical injury was documented and scored by the attending doctors according to the Injury Severity Score (ISS)[19,20] based on the Abbreviated Injury Scale (AIS). In the AIS, 1 represents 'minor injury', 5 'critical injury' and 6 'maximum injury, not compatible with life'. The ISS is calculated by the sum of the squares of the highest AIS codes in each of the three most affected ISS body regions. This results in an ISS range from 0 to 75.[19]

Level of psychological exposure was documented by scoring a few impact of exposure factors that are reported in literature as risk factors for poor mental health outcome; closeness to the disaster (in this study defined as being caught by the waves)[9, 21], experiencing life threatening situation[21], experiencing fear of death, physical injury to oneself or others and loss of relatives or friends.[4]

Interviews were complemented by a series of standardized questionnaires on psychological trauma, dissociation, depression and grief.[22-26]

Follow up

Longitudinal follow up was performed at two time points: after 6 months (T1, range 6-8 months) and after five years (T2, range 55-61 months).

At T1 physical examination, laboratory tests and psychological assessment by self-report questionnaires (among which was a quality of life assessment) were performed at the out patient department of the hospital.

Quality of life (QoL) was assessed with the EuroQol-5D+ (EQ-5D+).[27-30] The EQ-5D+ is a quality of life score designed for self-completion and consists of two parts: the EQ-5D+ self-classifier and the EQ-5D+ VAS. The EQ-5D+ self-classifier scores the severity of problems on a 3 point Likert scale (1= no problem, 2= some/moderate problems, 3= severe/extreme) on 6 dimensions: mobility (MO), self-care or autonomy (SC), usual activities (UA), pain/discomfort (PD) anxiety/depression (AD) and cognition (CO). The 6th dimension of cognition in the EQ-5D+ was added in a later stage to the original Euroquol-5D.

The EQ-5D VAS is a self-rated health status using a visual analogue scale (VAS) recording the participant's perception of his/her current overall health state. It ranges from 0 (the worst imaginable health state) to 100 (the best imaginable state).

The EQ-5D index tariff or utility score links a single index value to all hypothetical health states. Full health is represented by an index of 1.00. The EQ-5D index value was calculated by the Dutch EQ-5D index tariff for all possible health states defined by the 5D EQ self-classifier.[31,32] This index tariff we used is based on the 5 five dimensions of the original EQ5D, as an international validated tariff that weighs all 6 dimensions of the EQ-5D+ health states is not available yet, The 6th dimension cognition was therefore depicted separately.

Health related quality of life as measured with the EQ5D+ questionnaire has thus three different outcome sets: 1. amount of reported problems in each of the six EQ-5D+ dimensions 2. EQ VAS score and 3. EQ-utility score.

At 5 year follow-up (T2) the following assessments were performed: physical and psychological assessment (self-report only), quality of life (EQ 5D+), a self-perceived health status comparison to pre-tsunami, and assessment of use of health care. Health care use was divided in several categories; general practitioner care, specialist care (for example surgeon), physiotherapy, operations in the past year, psychological support, psychological medication, other medication (for example painkillers) and other care.

Data analysis

EQ-5D index values at 6 months and 5 years were calculated according to the Dutch TTO (Time Trade Off) method.[31,32] Prevalence of the separate domain-specific health problems at 6 months and at 5 years were obtained from dichotomization of the raw scores into "no/yes problems". The relationship between the EQ-5D index values and the EQ-VAS values was evaluated with the Spearman rank correlation test. Furthermore we evaluated relations between demographics, laboratory values, ISS and amount of psychological impact to the EQ-5D and EQ-VAS scores at 6 months and 5 years by using t-tests and Spearman's rank correlation tests. Also the EQ-5D and EQ-VAS scores at 6 months and 5 years were compared to those of an age- and sex-matched general Dutch reference population using paired t-tests.

Changes between 6 months and 5 years were also evaluated with paired t-tests. Changes in the dichotomized separate domain-specific health problems were evaluated using McNemar's tests. At 5 years the changes as of 6 months

in EQ-5D-index and EQ-VAS score were furthermore analyzed by multiple linear regression analysis. The following base set of explanatory variables was entered simultaneously in the model: the 6-months ("baseline") measurement of either the EQ-5D or EQ-VAS scores itself, age and gender. Additionally to this set of explanatory variables, the following variables were entered in he model one-by-one and tested for significance: ISS, died/missed loved ones, fear of death and education.
Use of care (physically and psychologically) was summarized by means of relative frequencies (percentage) and changes in care between 6 months and 5 years were analysed using McNemar's test.

Results

Findings on admission

Physical trauma

All patients demonstrated one or multiple soft tissue injuries, predominantly at the extremities. Eleven patients (58%) had a clinical wound infection at the time of admission. Swab results showed a combination of aerobic-anaerobic and waterborne bacteria and a high prevalence of Gram negative bacteria and enteric commensals.[16] Other diagnoses were fractures of pelvis (1) or foot (1), rib contusions/fractures (5), pneumonia (1), tendon lesions (2), commotio cerebri (1), plexus lesion accompanying soft tissue injury of shoulder (1) traumatic finger amputation (1) and diarrhoea (1). None of the patients needed ventilatory or circulatory support. The median ISS was 5, a range from 1 to 9. The extremities and the external region (lacerations, contusions and abrasions) were the most affected AIS regions. Six patients had already undergone surgery (predominately wound debridement, 1 finger rest amputation and one vascular repair) immediately after the disaster in Thailand, and in four patients wounds were opened or debrided on the ward in Thailand. Six patients were operated in our hospital. During admission no adverse events, complications or deterioration of clinical course occurred.

Psychological trauma; exposure

Level of exposure was quantified by: closeness to the disaster/being caught by the waves, experiencing a life threatening situation, experiencing fear of death, physical injury to oneself or others and loss of relatives or friends (*Table 1*). All patients had experienced danger to life and had been caught by the waves. The majority of the patients had a relative or loved one that was wounded (13/19), missing or deceased (8/19).

Table 1. Disaster related psychological exposure factors

	Patients (%)	
Being caught by the waves	19	100%
Experiencing life threatening situation	19	100%
Experiencing fear of death	19	100%
a little	*4*	*20%*
moderate	*2*	*11%*
a lot	*13*	*68%*
Physical injury	19	100%
Physical injury to relatives or friends	13	68%
Missing relatives or friends	8	42%
Deceased relatives or friends (after identification in later stage)	8	42%

Follow up at T1: 6 months

Seven patients (7/19) rated their present health worse than before the tsunami, 2/19 better and 10/19 the same. Thirteen patients used healthcare facilities for complaints related to the tsunami. This consisted of general practitioner care (7/19), specialist care (7/19), physiotherapy (5/19), operations (5/19), psychological support (7/19), psychological medication (1/19), other medication (0/19).
Quality of life as measured by the Euroquol 5D+ showed a mean EQ-5D index of 0.799 (sd 0.19, range 0.22-1.00). This mean is 0.08 points lower (95 % CI: -0.18 to +0.02; p = 0.10) than that in a sex- and age-matched Dutch reference population.
Of the dichotomized scores of the separate domains, "anxiety and depression" was the problem with the highest prevalence (*Figure 1a*).
EQ-VAS scores showed a mean perceived health rated at 78.35 % (sd 0.16, range 0.45-0.97). This is comparable to the Dutch reference population (mean difference 0.48; 95 % CI: -6.19 to +7.14; p = 0.88).

Follow up at T2: 5 years

At 5 years five patients still rated their present health worse than before the tsunami, better and 13 the same. Two patients indicated to be hindered in their daily functioning by their physical injuries. Five patients still felt hindered in their daily activities by the psychological sequelae of the tsunami. Altogether, 13/19 patients were not hindered by physical nor psychological complaints related to the tsunami in their daily activities, 6/19 were.
Ten patients still used health care facilities for complaints related to the Tsunami, consisting of general practitioner care (4/19), specialist care (3/19), physiotherapy (4/19), psychological support (2/19), psychiatric medication (1/19) and other medication (1/19). None of the patients had undergone surgery in the

Figure 1: Contributors to EQ score in 6 dimensions at 6 months and 5 years (dichotomized values)

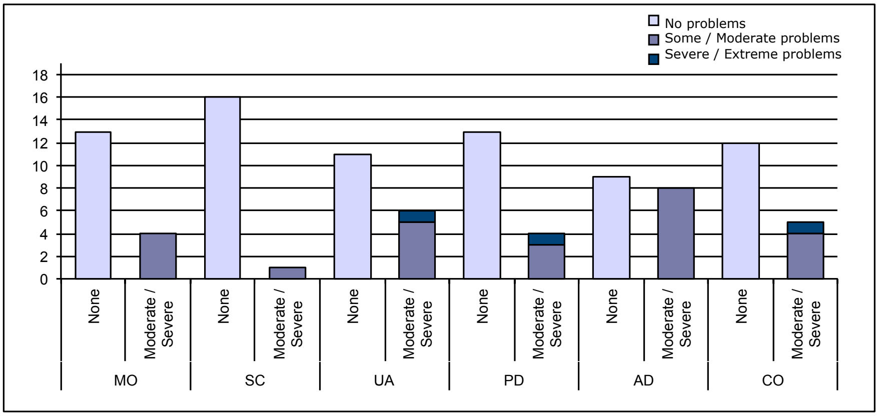

Figure 1a: Contributors to EQ 5D+ in 6 dimensions at 6 months (T1);
Mobility (MO), self-care or autonomy (SC), usual activities (UA), pain/discomfort (PD) anxiety/depression (AD) and cognition (CO)

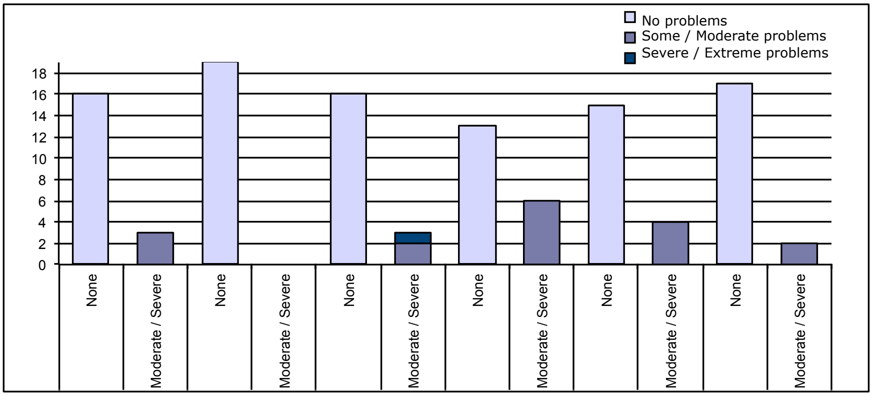

Figure 1b: Contributors to EQ 5D+ in 6 dimensions at 5 years (T2)

past year. The three patients that were using psychological therapy or psychiatric medication did not use this at 6 months post tsunami. All patients that did use this at 6 months did not use it at 5 years.
Quality of life as measured by the Euroquol 5D+ was better than at 6 months at a mean EQ–5D score of 0.89 (sd 0.16; range 0.39-1.00).
The difference with the 6 months value was almost significant with a mean increase of 0.08 (95 % CI of mean change: -0.00 to +0.16; p = 0.056).
Of the separate dichotomized domains, the problem "pain/discomfort" had the highest prevalence (*Figure 1b*). In none of the six separate dichotomized domains a significant change was seen compared to 6 months post-disaster using Mc Nemar's test.

EQ-VAS scores showed a mean of 79.63 %, almost the same as the mean of 78.35 % at 6 months (95 % CI of mean change: -5.4 to +6.1; p = 0.90).
Both mean EQ-5D score and EQ-VAS score at 5 years were not significantly different from those of the reference population (respective p-values 0.73 and 0.49). Relations of demographics, ISS and psychological trauma to EQ-5D and EQ-VAS scores were analysed with t-tests and Spearmans rank correlation tests. A higher ISS was related to a lower EQ-VAS score (correlation coefficient -0.53; p=0.030) after 6 months, but was not significantly related to lower EQ-VAS at 5 years or to EQ-5D scores at both 6 months and 5 years. Furthermore from demographics and psychological trauma only high age (correlation coefficient -0.56; p= 0.013) and lower level of education (correlation coefficient 0.52; p=0.021) were significantly correlated with a lower EQ-5D score at 5 years; no significant correlations with EQ-5D score were found at 6 months or with EQ-VAS score at both 6 months and 5 years.
Evolution in time of the EQ-5D and EQ-VAS scores was also evaluated. The effects of the base set of explanatory variables on the change of EQ-5D and EQ-VAS as estimated by multiple linear regression analyses are presented in *Table 2*. Older age and female gender seem to lower the chances of improvement between 6 months and 5 years (*Table 2*). As expected, also a higher starting level at 6 months of EQ-5D and EQ-VAS lowers the possibility for further improvement in those respective variables. None of the additional effects on the respective changes in EQ-5D and EQ-VAS score by extending the regression model with any one of the following variables appeared to be significant: ISS (p = 0.39; p = 0.97), died/missed loved ones (p = 0.88; p = 0.58), fear of death (p = 0.96; p = 0.55), and education (p = 0.20; p = 0.58).

Table 2. Results of multiple linear regression analyses: changes in EQ-5D and EQ-VAS scores from 6 months to 5 years after the tsunami (n = 17).

Dependent variable	EQ-5D change					EQ-VAS change				
	Coeff.	SE	P-value	95 % CI Lower	95 % CI Upper	Coeff.	SE	P-value	95 % CI Lower	95 % CI Upper
Constant	0.751					44.39				
Start level (1 point)	-0.472	0.148	0.007	-0.791	-0.152	-0.36	0.16	0.046	-0.71	-0.01
Age (1 year)	-0.006	0.002	0.017	-0.011	-0.001	-0.27	0.16	0.120	-0.62	0.08
Gender (female)	-0.115	0.057	0.066	-0.238	0.009	-12.58	4.11	0.009	-21.46	-3.71
Residual sd	0.105					7.97				
Adj. R squared	0.58					0.49				

Discussion

Our results demonstrate that quality of life at 6 months and 5 years was non-significantly lower in injured subjects after exposure to natural disaster at a group level than a reference population. A quarter rated their health five years after the trauma as worse than before the disaster and a third still felt hindered in their daily activities 5 years post disaster. Use of health care for trauma related complaints dropped from 68% at 6 months to 26 % at 5 years. All patients in our study sample were directly hit by the waves and all had wounds, some with additional other physical injury. Injury severity scores were relatively low on admission in the Netherlands. This may be explained by the fact that these were measured five days after the tsunami and that the group was a selection of patients that were fit enough to travel and to be repatriated. The level of exposure to psychological trauma though was high; all patients in our study sample experienced danger to life and had been close to the disaster (caught by the waves). The majority of the patients had a relative or loved one that was wounded (13/19, 68%), missing or deceased (8/19, 42%). From the 500 Dutch persons present in the disaster area, in total 36 people were reported missing. Identification of the deceased took a long time, in some cases weeks to months. This period of uncertainty resulted in a lot of additional emotional distress for our patients. None of the missing relatives of our patients were found back alive.

The quality of life scores (EQ5D+index and VAS) at follow up seemed lower in our population than the Dutch sex and age matched reference population, and the mean of the group seemed to improve over time. These differences though were not statistically significant. However, when patients were asked to compare their health with the situation before the tsunami, 7/19 at six months and 5/19 at 5 years rated their health as worse than before the disaster. After 5 years 6/19 still felt hindered in their daily activities by complaints related to the tsunami. Use of health care for tsunami related complaints was rather high; 13/19 of patients at 6 months and still 10/19 after 5 years. This was not expressed in a significantly lowed EQ-5D index or VAS scores compared to the sex and age matched reference group however. This could be explained by several factors. First, the group of included patients remained small, which makes it difficult to produce statistically significant differences. This is an important limitation of our study in general. At the start of the study more patients were expected to be repatriated, but eventually only the current group studied was collectively repatriated to the MIH. Secondly, properties of the Euroquol as outcome measure can play a role. The Euroquol has the advantage of conciseness. This instrument proved suitable for describing the health status of the general population, but some detail may be lost. Feasibility, coverage and discrimination are comparable to other instruments like the SF-12 an the modified HUIE3.[33, 34] Disadvantage is that it is less sensitive at the milder end of health distribution and that the index scores that can be compared to the reference population contain no items that cover cognitive abilities.[30, 33, 34] Thirdly, our study sample was characterized as a socioeconomically stable, employed and highly educated group, mostly with a partner; factors that have proven to be significantly related to better outcome in all Euroquol dimensions.[35] Men are slightly overrepresented and generally rate their health better, but this should be neutralized by the fact that we compared to the sex and age weighed index value.[31,32] Altogether this group is expected to have a higher baseline EQ-index and VAS score than the mean of the reference population. Due to the nature of the study population no pre-disaster quality of life scores were available for this group to serve as a reference for its own post disaster values. Last, a health related quality of life judged as good while health complaints are present might indicate post-traumatic growth.

Of all factors, ISS only showed to negatively influence the EQ-5D-VAS score after six months. A long term impact of severity of injury on health related quality of life was not observed. High age (correlation coefficient -0.56 p= 0.013) and lower level of education (correlation coefficient 0.52 p=0.021) were correlated with a significantly lower EQ index at five years. These factors have also shown in literature to be of influence on mental health outcome and PTSD development after disasters.[1,9] Less is documented about the influence of these factors on quality of life outcome after disasters. In measurements of quality of life in the general population though these factors seem to influence self-rated quality of life negatively.[35]

After 5 years 6/19 of subjects studied still indicate to feel hindered in their daily activities by their physical and/or psychological complaints related to the tsunami. The high impact on daily activities as well as the high demand of health care for tsunami related complaints, both physical and psychological demonstrate the need for a combined approach with physical and mental health care for this type of patients. This combination of factors is supported by literature, which shows that there is a relationship between mental and physical consequences of trauma.[36] Moreover, mass trauma produces long term physical health consequences that put a burden on care long beyond the first months.[37] Our results show that this type of trauma can have a long term and sometimes delayed impact. Patients in our study with psychological care at 5 years had not reported psychological problems before and sought for psychological help even years after the tsunami. Morren and colleagues also found evidence for delayed increases in symptoms in rescue workers, years after the disaster.[10] In their study sick leave for physical complaints remained high after three years while leave for psychological problems had returned to predisaster level. In our study, "anxiety and depression" scores had the highest prevalence at 6 months after the initial event, whereas at 5 years "discomfort and pain" scored more predominantly.

Conclusions and recommendations

Exposure to the 2004 tsunami had a considerable middle and long-term physical and emotional impact in our sample of repatriated injured patients. More than one third of the patients still feel hindered in their daily activities by tsunami related complaints after 5 years and the use of health care for these (both physical and psychological) complaints is rather high. Outcomes in quality of life scores as measured by the Euroquol score do not reflect this as significant differences when compared to the reference population. This can be explained by the measurement and sample characteristics as by the fact that this was a well educated, socially stable group. Our sample was of small size. However, our results show that this type of trauma can have a long-term impact and that some disaster related effects may not emerge until years after the event. This calls for long-term attention for this kind of patients.
Combined, long-term studies may disentangle the impact of trauma on both bodily functions and emotional impact. This may also enable improvement of a combined approach of medical and psychological support in the course of acute care and follow up of those being injured after a disaster.

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Chapter 7

Use of a Web Portal for Support and Research After a Disaster - Opportunities and Lessons Learned

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Abstract

Background

In this report we describe the development and use of a web portal in the aftermath of the 2004 tsunami. This large scale disaster confronted many displaced people with death, despair and need for information and support. Awareness and insight in the emotional impact of disasters can provide opportunities for surveillance and early treatment. Moreover, online support systems can contribute to community building, empowerment of victims and resilience.

Objective

We evaluate the development of a multilingual web portal that combined a platform for information, emotional support, self assessment and referral with research opportunities. The rapid development, use, advantages, difficulties and learning points are discussed.

Methods

Inspired by a group victims of the tsunami repatriated to the Netherlands a multidisciplinary working group from the University Medical Centre Utrecht, the Major Incident Hospital and the Central Military Hospital developed a web portal that combined 1. a forum aimed at community building; 2. self assessment tools and a research survey; 3. e-consultation and 4. an information portal.

Results

Within 3 weeks after the tsunami, an open, online service (www.TISEI.org) was launched to foster (community) support in the aftermath of the disaster. It combined four functionalities that were earlier only used separately. The portal had over 36.800 unique visitors in the first two years. At least 29 percent of the Dutch victims could be reached for a survey through the site. The TISEI-environment was available in 15 languages and visitors came from all over the world. Of all visitors, 95% came from Europe or the United States. In the long run, the web portal also served as a memorial archive for anniversary meetings and follow-up incentives. Difficulties we experienced were lack of funding, time pressure, victim- anonymisation, international collaboration and long term maintenance.

Conclusions

Web-based services like www.TISEI.org in the aftermath of mass disasters can help community building and deliver low level, patient centred and easily accessible information and care. A multilingual website with combined modalities for emotional care and research after a natural disaster proved feasible. Growing Internet penetration world wide and especially the rapid expansion and influence of online communities enables delivery of care and perform re-

search with the Internet as a platform. The unpredictable nature of disaster does put time pressure on the development of online solutions and influenced the yield of our site. This highlights the necessity of developing methods and (inter) national collaborations in advance, secure funding, and learn from earlier initiatives.

Introduction

On December 26th 2004, a massive undersea earthquake caused a giant shockwave or tsunami that devastated the shorelines of Indonesia, Sri Lanka, India, Thailand and many other countries. Some hundred thousands of people from all over the world were reported missing or dead. Most victims were local citizens. Many foreign tourists who were celebrating their Christmas holidays were also hit and hundreds were killed by the waves and the flooding of debris. Large numbers of survivors were repatriated from countries around the world to their home countries. Among the 500 Dutch visitors in the region, 36 were killed. Several were wounded and were repatriated home in the following days. On January 1st 2005, 23 injured survivors were flown to the Major Incident Hospital (MIH) in Utrecht, the Netherlands. A spontaneous call for a communication platform was heard, in which survivors would hope to connect with the community they were part of as well as other survivors. In the days after the tsunami numerous web logs and local initiatives were soon posted. In response to the call of these survivors we decided to start an initiative for online fostering of resilience by providing information, enabling contact among affected persons and facilitation of connection with professional mental health care workers.
In disasters, besides death toll, physical trauma, destruction and economic consequences, the psychological impact can have far-reaching and long-term consequences. Experiencing a traumatic event in which an individual is exposed to death, or serious injury of the self or others can have dramatic and long lasting consequences for mental health. The most notably measured long term effects of coping with destruction, trauma and loss are PTSD and depression.[1, 2]
Earlier studies demonstrated that knowing that there were other survivors can reduce feelings of isolation and have a preventive effect on later psychological problems.[3] Fellow survivors can provide mutual support that may be perceived more meaningful than outside help. Online support systems can make a contribution to community building. The value to participants of such virtual forums designed to give and receive emotional support has been documented, although the effect of online communities in " regular " mental health care per se has not been unequivocally established with high quality scientific evidence yet.[4-7]
Disasters are events that invite a public health approach; we need to engage existing services with strategies to extend mental health care as well as the distribution and availability of resources. The rapid growth of Internet and influence of online communities already in our lives illustrate its opportunities to foster resilience and deliver care after catastrophic events.

Besides mutual support, the Internet can enable self-assessment[8, 9] and self-referral. This can stimulate empowerment and a kind of self-triage, which could prevent morbidity like PTSD and depression in the longer term. Furthermore it could be an instrument to assess the emotional impact of the Tsunami on a group level. Earlier online initiatives in the aftermath of disasters, like surveys after "9/11"[10, 11] show the potential of the Internet for health and disaster related research. Awareness and insight in psychological impact of natural disasters on the survivors and the community as a whole has the potential to improve quality of information and support and to aid in planning early treatment options.
In this paper we report the development and use of a web portal as an aid in the management of emotional impact after the Tsunami disaster. We evaluate the feasibility, launching speed, and the development process of a multilingual site that combined a platform for emotional support, self-assessment and referral with research opportunities. The strengths, the faced difficulties and our learning points are discussed.

Methods

Two days after admission of the patient group to the MIH the chairman of the executive board of the University Medical Centre Utrecht (UMCU) granted support to develop the web portal project. Extensive and sufficient funding for building and hosting the website was not present at the time we started. It was gradually formed along the way. Most of the researchers were clinicians (psychiatrists, surgeons, psychologists) or IT-specialists that voluntarily added the task to their normal job. In the first weeks after the Tsunami there was a unique collective atmosphere in which many doors were opened. Within 3 weeks after the Tsunami, an open, online service (www.TISEI.org) was launched to foster (community) support in the aftermath of the disaster.
We developed a web service with four functionalities (*figure 1*):

1. Information portal; to provide disaster-specific and relevant information. Numerous websites provide information about the impact of disasters. By making a specific disaster based service the site helps directing to those that are relevant and up to date, and are specifically chosen for the victims. In addition we selected services that provided health related information.
2. Forum; to facilitate building a community of support for survivors and their loved-ones. This could be through telling personal experiences of the disaster by choosing the web service as an open diary. This general forum had an open, public character but it was also possible to have a private conversation. Participants could connect 'back channel' after registering, which enabled them to communicate with their (registered) peers only. The forum

was intended for victims, support groups, helpers and others to share their concerns and express their feelings. A Webmaster monitored content and language. Each language portal had its own forum.

3. Self-assessment and "open" Web-based survey; this functionality facilitates confidential self-assessment and offers a way of getting grip on feelings through a series of scientifically validated questionnaires.

The survey was tailored to assess ones own mental health and obtain a reasonably reliable recommendation whether to seek psychological help. The web survey provided feedback and allowed the participant to print the questionnaire to keep for themselves or take to their counselor or physician. The online forms could also be used for the e-Consult tool on the site. Furthermore results allow cross-sectional as well as longitudinal research. The survey started with questions about demographics, pre-exposure health and specifics about the stay in South East Asia. These were followed by a compilation of validated existing questionnaires and non-validated questionnaires that could reveal valuable information regarding mental health problems, such as sleeping problems. Among the structured questionnaires were assessments of the impact of events[12], trauma[13], peritraumatic dissociation[14], emotions, general health, sleep[15] and of depression.[16] For those who had lost a loved one a grief questionnaire was added.[17] After 6 months a quality of life scale was added[18] but this had to be removed soon due to copyright issues.

Prior to starting the self-assessment, participants had to give informed consent and register to receive a password by email to enter the survey. Further details of the design of the survey module are depicted in appendix 1 according to the relevant parts of the CHERRIES checklist.[19]

4. e-Consultation; a functionality for online confidential consultation services of professional mental health workers. It offers easily accessible advice on (mental) health issues, including personal advice about the necessity and location of treatment. It enables victims to seek help for symptoms of emotional distress either through online consultation or referral to a counsellor in their own region. The service request would be posted anonymously by email, forwarded to a mobile phone of the on call team and followed up only by email. E-Consult use was only available after registration to the web service and after completion of the web survey. This part could be hosted separately in different portals to accommodate victims with an advice relevant to their region of residency.

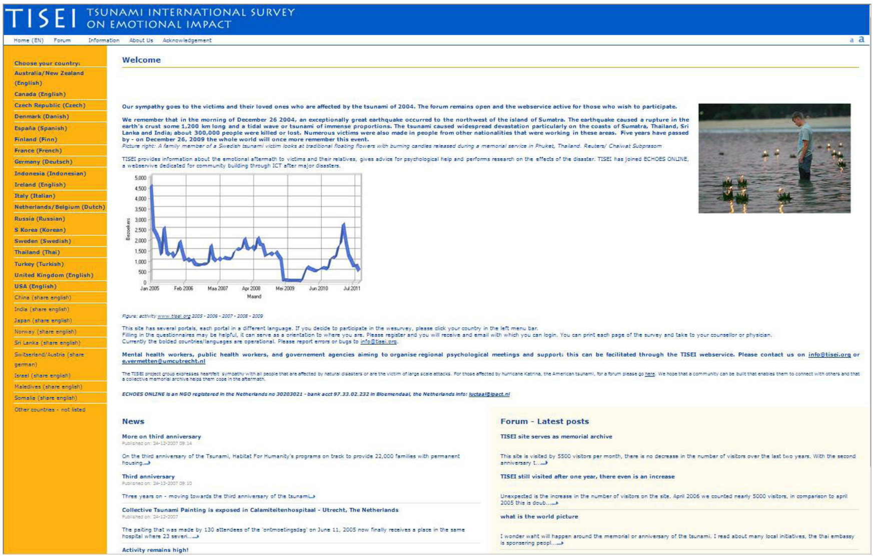

Figure 1. Example of one of the pages of TISEI environment (*www.TISEI.org*) with multilingual portals (15 different languages), the forum and information portal.

The self-assessment/survey and e-Consult option is visible in the language portals. Server capacity was arranged with external providers. Building and hosting of the actual site was outsourced to a company that builds Internet solutions and that had assisted in earlier projects. The site was hosted in the Netherlands and mirrored to warrant data integrity. The framework of the site was language independent, which made it possible to create a local version within a day and make quick multilingual changes.

All personal information was secured with logins verified by registered email and therefore accessible only for the individual participant. Personal information that was entered in the Web survey was anonymous through a pseudo anonymisation procedure that meets the criteria of European law. Others than the participant and the researchers could not retrieve the results of the survey. The database was accessible for the research team through a password secured login. For the content of the web survey we adapted the questionnaires to Internet research and applied for permission for copyright measures. Professional translators assisted us to achieve multilingual portals.

The entire TISEI-environment was language independent and region independent. Web platforms for online support were made available in 15 languages including: English, French, Spanish, German, Italian, Russian, Dutch, Danish, Finnish, Swedish, Turkish, Czech, Korean, Thai and Indonesian.

Each language portal could have its own user group that could be modified and shaped to a preferred style, with local information and services—as long as the Web surveys remained similar. Each user group could build a database of Web surveys of its own. By building a local team of consultants, each portal could offer local user groups in different countries the opportunity to provide regional psychological support through the electronic consultation service.
When the setup was finished, the Institutional Review Board of the UMCU assessed and approved the developed website format and study protocol of the survey according to prevailing ethical standards.
Within two weeks the prototype of the site was tested with different providers and computers. We tested ease of use, clarity of instructions, safety and user friendliness.
Potential site users and participants in the survey were recruited through several means. We attached keywords to relate to search engines. We issued a press release and international news media and organisations were contacted like the International Society for Traumatic Stress Studies (ISTSS), the World Health Organization, World Psychiatric Association and the United Nations.

Results

Visitors to the Website: use

The total number of unique visitors in the first two years was 36.849 (January 14, 2005 until January 1, 2007). This is based on unique IP addresses entering the site. These numbers peaked in January 2005 with 4.587 visitors within the first 18 days of the website. The average number of visitors per month was 1473 varying between 4587/month and 789/month. The first quarter of 2006 –one year after the Tsunami- showed an upward trend in terms of visitors, hits, and bandwidth compared to the eleven months before. This was even more clearly visible in December 2007 (*see figure 2*).

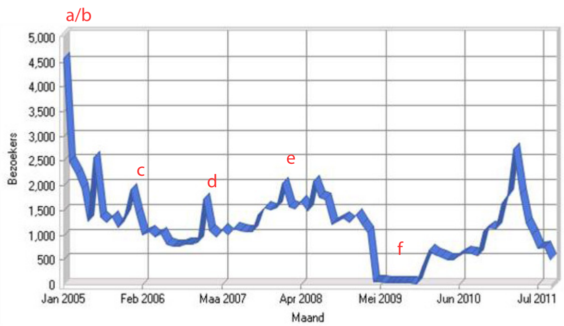

Figure 2. Number of visitors per month on the TISEI site

(a) Tsunami
(b) Launch of website
(c) 1 year after tsunami
(d) 2nd anniversary
(e) Invitation 2nd wave of survey (3 years after tsunami)
(f) Website offline

The website was offline for more than half a year in 2009 due to maintenance and funding issues. Fall 2009 the website was live again. It showed an upward trend around the 5th anniversary of the tsunami December 2009.
The European countries and the United States together made up 95% of all visitors to the site. Most of the European visitors were Dutch (*see figure 3*).
Links on other websites did not result in substantial visitor recruitment; they contributed for less than 2% tot the total of visitors. Most visitors of the TISEI environment directly went to the URL or found the site when searching with keywords as "tsunami" (in different languages and with English, Dutch and further predominantly Turkish words attached), "TISEI" or names of victims.

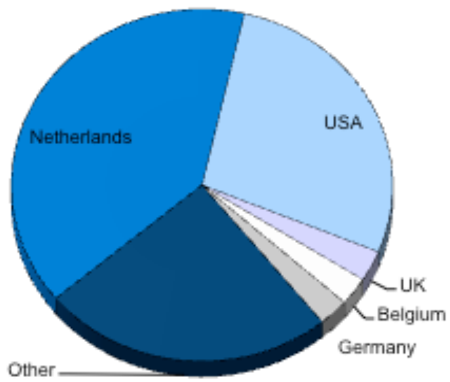

Figure 3. Activity on the site depicted by country of origin

Forum

The forum contained a lot of individual stories of victims as well as responses of people who read the narratives and offered to act as a sounding board or to give explicit help. Examples of these vignettes were more extensively described elsewhere.[20] People described their experiences and emotions. They expressed their symptoms, concerns and complaints, and shared their evaluation of initiatives they had undertaken for treatment. When reading the narratives it becomes clear that the e-forum served as a place of mutual support and help. This has also been true for children, illustrated by this contribution on the public part of the site: *" I read your story (..) and began to cry. It was so familiar to me! I was also in Thailand during the tsunami, I think it's so brave of you to talk about it. I would like to talk about it with people our age, I've been looking for just that and then I found this Website. It's good for me to know that I am not the only one with this awful story, I hope we can e-mail (etc) with each other."*

It proved difficult to organise international partners agreements for collaborative use of the multi-language facilities. This mainly affected the survey and e-Consult parts of the site. For example Sweden opened a portal but decided to perform a paper and pencil questionnaire instead of participation in the online survey.
For this paper, we only analysed use of the confidential part of the site in our own Dutch portal.

Self-assessment and survey; the Dutch sample

The Web-based questionnaires were all in a password protected area of the site. Informed consent was obtained from all participants of the self-assessment to be included in the database of the survey on emotional impact.
The number of Dutch citizens in the tsunami area at the time of the disaster was estimated to a number of 500 of which 36 died in Asia. Through the Dutch portal 144 persons participated in the TISEI survey and filled in 175 assessments. These people were not directly invited by e.g. email but encountered the survey on the site.
The response rate, expressed as the number of people completing the questionnaire divided by those who viewed it[21], view rate (ratio unique site visitors/ unique survey visitors)[19], or participation rate (ratio unique survey page visitors/ agreed to participate)[19] could not be calculated in retrospect due to technical properties of the site. The completion rate expressed as the number of people completing the questionnaire divided by those who agreed to participate[19] it was 95%.
After three years a secondary measurement was performed in which 39 Dutch survivors participated. Matching the results of participants over time proved to be difficult due to the method of anonymisation through pseudo anonymisation.

e-Consult

As referral or treatment advice is a local or national issue, this part was supported by each country itself with its own "back office" with their own arrangements with actual care providers. In the Dutch sample 31 people used this modality to consult a professional mental health care worker. All questions could be answered within 24 hrs, except for 3 questions posed in a period of a sick consulent and a non-redirection situation of emails. Besides that, the e-Consult functionality worked well and we did not meet any technical problems with this feature.
After two months a lot of patients expressed PTSD associated symptoms like insomnia, nightmares, irritability, avoidance and flashbacks. Even after one and two years people contacted through e-consult of the TISEI site looking for help

for nightmares, anxiety, concentration problems and weight loss related to the Tsunami.

Twenty one patients were referred through the site to a mental health care worker for treatment or further advice. Other patients could be helped through online advice and sometimes repetitive contacts. To our surprise, some of the ' referrals' to care providers were done by peers through the forum.

Satisfaction and feedback of visitors

Satisfaction about the website was not quantitatively measured on the website but we received numerous emails of users as well as positive reactions on the forum. The patients admitted to the MIH completed an inquiry and were very positive. The site was rated at 8/10. The information portal was valued as the least part. Improvement ideas from users regarded graphical issues and e.g. a counter of messages and more information on e.g. coping with stress and sleeping problems directly on the site in stead of providing links.

Discussion

Opportunities

The TISEI web portal was the first to combine different features of online services used separately in earlier online post disaster initiatives[9]; a platform to foster community building combined with self assessment questionnaires, offered in conjunction with e-Consultation for referral options and a research survey. All four different functionalities can enhance each other's usability and potential reach. In this way the portal could serve as a basis for support primarily without interference of health care providers, but with a coupled gateway to professional mental health care and research.

Self-help through providing adequate, relevant information and a forum serves patient, or better said, people empowerment.[22, 23] Feelings of self-control can be enhanced though recognition and contact with peers to help to process their own emotions and experiences. Knowing that there are other survivors can reduce feelings of isolation and have a preventive effect on psychological problems.[3] Empowerment after traumatising events is a powerful tool to diminish the severity of complaints in the acute phase, which helps to avoid development of chronic complaints. Not only is Internet penetration growing rapidly, as in other fields than mental health, online communities have become important platforms where people exchange experiences and seek advice. The reactions in the forum show that the objective to help coping with the impact of a disaster and to help fostering resilience was met.[20]

Online self-assessment further contributes to this by offering people an easily accessible, flexible and anonymous tool to synthesize their feelings and asses their own mental health. Earlier studies report that self-assessment or a research survey itself can also be experienced as an intervention. It showed to provide an opportunity for emotional expression, cognitive processing, restructuring of the experience and active coping.[9] Through the TISEI site, several participants reported the same experience and expressed their appreciation of interest in the emotional aspects of their response.

The Internet application like the TISEI environment with a survey module bears great research opportunities. At the same time it confronted us with several logistical as well as scientific challenges as will be discussed in the next paragraph. Rapid response, standardized answers that are directly saved in a database, cost-effectiveness[24] and global reach are just some examples of its advantages.[25] The identification of individuals at risk for PTSD following a disaster may help organizations prevent both the human and the economic costs of this disease.[24] Several studies showed that sensitive topics, such as psychiatric symptoms are more likely to be reported in self-reported assessments than in interview-based assessments and computerized forms are a good alternative. Web-based data collection has a potential to reduce social desirability bias.[26-28] Studies of responses to disaster have a necessarily observational and post event nature which makes it difficult to identify true causal relation ships between exposure and observed outcomes. Reducing selective attrition remains a challenge in any health survey. As in almost every survey after a disaster, TISEI participants form a volunteer sample of convenience rather than probability sample.[29] This bias is not due to Internet use and could even be diminished by it, as it also includes people that did not seek professional help, in contrast to interview studies among (self) referred patients. Combining research with support groups and self assessment might further improve patient recruitment bias compared to a research site alone.[21,30] People not looking for research or self-assessment will come across the survey while visiting the TISEI site for the forum or information.

Although surveys like TISEI will not provide causal incidence data, empirical evidence and qualitative research of the impact and adjustment process after disaster exposure will aid clinicians in designing interventions for individuals coping with negative outcome.[1] For in dept understanding of experiences of particular individuals or groups, qualitative aspects are as important as quantitative.

This study shows that 29% (144/500) of the Dutch tsunami victims from the Netherlands could be reached for participation in the survey through the TISEI site.

E-Consult. We believe that offering a self assessment and/or a survey should be accompanied by an e-Consult or phone service for participant safety. Focussing

on the details of these topics might exacerbate distress in an already distressed participant[31] and therefore professional help and/or referral options should be arranged for in advance. These can at the same time benefit from information provided through the self-assessment.
Online consult modalities can offer rapid client centred emotional care. Many clients may not seek help otherwise because of stigma or lack of information. It is a low level and accessible way to pose health related questions to a professional and can assist to seek help in ones own geographic region.

Moreover, the web service was unique in that it was language and region independent. Due to the largely tourist nature of the disaster region, survivors came from all over the world. To be accessible to this broad and diverse group of survivors it was necessary to translate the TISEI-site into several languages. This differs from many earlier online initiatives like after 9/11[9,11] that were mainly national/English.
Although the TISEI web service was available in 15 languages including Thai and Indonesian, 95% of the visitors were of European or US origin. The finding that relatively few survivors from Thailand, Indonesia and Sri Lanka visited the site may be related to a number of factors. First, major global differences in Internet penetration play a role. Statistics from Internet World Stats[32] reported Internet penetration in the United States in 2006 of 68 per cent. The European average penetration was lower at 36 per cent. Seventy eight per cent of Dutch households had Internet access at that time. The areas hit by the tsunami however, had penetration levels of 9.9 (Asia) and 2.6 (Africa) per cent respectively. Secondly, destruction of the already limited Internet infrastructure by the tsunami will have further lowered Internet availability in Asia and Africa. Thirdly, focus on survival and rebuilding a home and life in this group of survivors might also have prevailed above initiative to think about ones personal mental health, in contrast to tourists that returned to their own non-devastated country after the disaster. Although there was less utilization of the web platform by visitors from Asia and Africa probably due to the afore-mentioned reasons, given the current and further anticipated rapid growth of the Internet, the development of an online multilingual psycho trauma information system holds great promise for the future.

Lessons learned

Apart from the opportunities of the TISEI site, we encountered a lot of challenges, both organisational and scientific, along the way. There are several lessons to be learned that most convolute to 1. penetration 2. cross country collaboration 3. funding 4. set up of the survey and 5. time-pressure

Penetration
As discussed above, although the site was multilingual and had global potential, most visitors came from Europe and the United States. Apart from the above mentioned reasons, the disappointing global penetration can also be attributed to an inability to establish firm international collaboration and media attention/participant recruitment.
Cross country collaboration
Cross country collaboration is mandatory to reach the international population, both for patient recruitment and funding as for concrete hosting of the portal to accommodate victims with an advice relevant to their region of residency.
The Swedish, German and Canadian partners were close to collaborating but stranded on formal bases. It was not clear which organization was entitled to decide and had authority.
Funding
It is no surprise that funding is a crucial but rare prerequisite for innovative acute disaster projects like this. Even though in the Netherlands only 125 Million EUR was collected on a single promotional night, this money was dedicated strictly to the rebuilding of the local community. No fundraising was successful for care for tourist victims or for an international service that had not been proven to be effective yet. Waiting for full and secure funding would interfere with timeliness as was also experienced in other projects.[9] Securing quick-response funding, time and people to set up the project turned out not to be the only problem; compared to later, the acute phase opened many doors for support. Long term funding to maintain the website, manage acquired data and do research on the results proved even more challenging. This interfered with site maintenance, follow up recruitment and result analysis. It was only close to five years later that a grant was awarded to further develop the service for future (Dutch) victims of traumatic events. After three years however we had had difficulties to keep the site online while it could have an important function as a memorial archive, as seen with other sites.[33]. These narratives could also be seen as a collective history of the disaster, as these are descriptions of people's unique trauma experiences, which are publicly accessible.
We were somewhat surprised by the increase in visitors in the first trimester of 2006 and 2007. This was probably explained by the anniversary of the tsunami-disaster. Even after two years the site had over 1000 unique visitors a month. Experience from previous disasters has shown that long term help is essential, particularly during and around the anniversary of an event and needs to be extended past the first year [34-36.] On the TISEI site after 2 years people still used e-Consult. Prospective 5 year follow up of tsunami victims admitted to the MIH also showed that onset of late symptoms can be after several years. As the

e-Consult feature had to be discontinued at that time, patients reported experiencing difficulty finding the right help.

Survey set up

Caused by technical aspects of survey setup, difficulty of matching respondents in time greatly influenced research possibilities of the site. Secure log inns were sent to participants by email when they participated in the survey. These could theoretically be used for long-term follow up, but due to the method of anonymisation we used and e.g. changes of (email) addresses, independent entries in time could not be matched to the same patient automatically. Part of them could be matched manually but this was a time consuming effort with incomplete results. For the same reasons, recontraction of lost to follow up survivors was more complicated than expected. Even though multi time point research was possible, true longitudinal follow up was impossible and results could only be analyzed cross-sectionaly. One question list turned out to be an incomplete version and therefore not validated. Not all instruments we wanted to use could be incorporated due to copyright issues.

Unfortunately, the potential for self-selection bias could not be estimated by measuring the response rate, view rate or participation rate as this was impossible to calculate in retrospect due to technical properties of the site. Checklists like CHERRIES[19] can not only help to improve papers reporting Web-based surveys but can also help in the starting phase as a checklist for quality of survey set up, together with reports on similar initiatives.[9] At that time we were not aware of the CHERRIES checklist but for example participation rates would have been easy to calculate now if we would have made minor adaptations in the site back then.

Time pressure

Many difficulties we experienced arose from the time pressure to quickly make the service available after the unexpected disaster. For both support and research timeliness is important. We managed to launch the site within 3 weeks after the tsunami to foster (community) support in the aftermath of the disaster. There was little time to develop the template for the site, design a survey study, select and adapt questionnaires, and get approval of Institutional Review Board. A lot of issues as copyrights, securing patient information and data, referral systems etcetera had to be sorted out on short notice.

As time proved to be a limiting factor in optimizing the design of the website, study and funding, we now started a project to develop a template site. Although disasters are unpredictable in timing and nature, many factors involved in providing a site for online community building, e-help en research will be similar and can be sorted out in advance to maximize possible yield.

Conclusions

The TISEI project, set up as a multilingual website with combined modalities for psychological support and treatment as well as research in the aftermath of the tsunami disaster proved feasible. It could be launched quickly and was operational within 3 weeks after the disaster. It fostered community building combined with self-assessment questionnaires, offered in conjunction with e-Consultation. Combining this psychological support with research proved feasible. Self-assessment served as an 'emotional thermometer', and the outcome was fed back to the research participant. All four different functionalities of the site can enhance each other's usability and potential reach. In this way the portal could function as a basis for support primarily without interference of health care providers, but with a coupled gateway to professional mental health care and research. Combination of information and self assessment with offering of treatment or help is mandatory for patient safety. Furthermore, it can help to identify people that need treatment in an early stage.
Web-based services in the aftermath of mass disasters can be an aid in community building and deliver low level, easily available and survivor centred information and support. It has potential for support, care and research with rapid response, cost- and means-effectiveness and global reach.

Time proved one of the most important factors in optimizing design and implementation of the survey in our study and in literature. Patient privacy should be a prime. Yet, for longitudinal analysis the anonymisation procedure should allow for returning participants to be identified. Securing funding and available people to manage the site and its contents proved challenging. Long term funding and maintenance has to be taken into account as even after a few years people look for help and the narratives serve as a collective history memorial.
Despite hurdles and lack of penetration to a global outreach, the growing Internet penetration as well as the rapid expansion and influence of online communities should be an incentive to further optimize care and perform research with the Internet as a platform. The unpredictable nature of disaster puts time pressure on the development of online solutions and influenced the yield of our site. Our lessons of the tsunami Web service highlight the necessity of developing methods and (inter)national collaborations in advance, secure funding, and expand the potential to other survivors of mass (psycho) trauma.

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Appendix 1. TISEI ; Web-survey of emotional impact ; Checklist for Reporting Results of Internet E-Surveys (CHERRIES)

Category	Item	TISEI Web survey
Design	Target population	Tsunami survivors
	Sample	Convenience
Institutional Review Board (IRB) approval and informed consent	IRB approval	Yes
	Informed consent	Informed consent page when applying for a password to enter the survey. Goal of study, researchers and length of time were disclosed as well as possibility to quit any time. Data were stored anonymously, only linkable to person by participant himself and researcher.
	Data protection	Website is hosted in a secure hosting location of KPN (leading telecommunications and ICT service provider in the Netherlands) with hardened security policies. Website and database were placed on different servers protected by firewalls
Development and pre-testing	Development and testing	Questionnaire is developed with mostly existing questionnaires. Acceptation environment where the survey could be pre-tested with different browsers and computers before published
Recruitment process and description of the sample having access to the questionnaire	Type of survey	Open
	Contact mode	Initial contact with the potential participants on the Internet
	Advertising the survey	The survey was announced at the web site that also contained an online community and information portal. Press and several organisations were informed about the site. Link on the ISTSS to the TISEI site. Offline media as newspaper articles.
Survey administration	Web/E-mail	posted on a website (after secured login, provided by email)
	Context	Web site solely dedicated to the Asian tsunami with information, forum, self-assessment and e consult modules
	Mandatory/voluntary	Voluntary survey
	Incentives	No incentives
	Time/Date	2005-2009

Appendix 1. Continued

Category	Item	TISEI Web survey
	Randomization of items or questionnaires	No
	Adaptive questioning	No
	Number of Items	6-34 items per page, 1 section 90 (SCL-90)
	Number of screens (pages)	14 (12 sections plus introduction and ending page)
	Completeness check	Questions were checked if an answer was supplied with JavaScript. Selection of a response option (including "different") necessary to continue to next page.
	Review step	respondents were able to review and change their answers through a Back button
Response rates	Unique site visitor	Based on IP addresses
Not possible to calculate	View rate (Ratio unique site visitors/unique survey visitors)	Not possible to calculate
	Participation rate (Ratio unique survey page visitors/agreed to participate)	Not possible to calculate
	Completion rate (Ratio agreed to participate/finished survey)	95%
Preventing multiple entries from the same individual	Cookies used	For the survey functionality, no cookies were used
	IP check	IP address of the client computer was not used to identify potential duplicate entries from the same user (often more victims in the same family)
	Log file analysis	Multiple entries with the same inlogcode were detected by the log file analysis. Multiple entries in time by same user (with different inlogs) could sometimes be identified manually by name and postal code.
	Registration	The survey could be filled in by the same user at multiple time points. No entries in the same timeframe (eg 3 months) were observed.
Analysis	Handling of incomplete questionnaires	All questionnaires were taken in to account, including which were terminated early
	Questionnaires submitted with an atypical timestamp	No timeframe used as a cut-off point
	Statistical correction	Not applicable

Chapter 8

Disaster-related injury and predictors of health complaints after exposure to a natural disaster; a long-term cohort study.

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Abstract

Objectives

To study the short and long term effects of experiencing a natural disaster in repatriated of injured disaster survivors, and the differential effect of injury, need for medical treatment, loss of loved ones and danger to life on both physical and mental health.

Design

Prospective cohort study.

Setting

Open online survey among Dutch survivors of the 2004 Asian tsunami.

Participants

Of the estimated total of 500 Dutch survivors, we recruited 144 unique respondents (59 males and 85 females) with 175 assessments at various time periods.

Main outcome measures

Health outcomes were: Symptom Checklist 90 (SCL-90), Impact of Event Scale, and Beck Depression Inventory II. Correlations were calculated with socio-demographic as well as disaster-related factors: physical injury, medical care, loss of loved ones and duration of threat to life. Assessments were clustered in 4 post-disaster time periods (0-3, 4-6, 7-30 and 31-48 months).

Results

Across these periods, SCL-90 scores were significantly higher than the reference population ($p < 0.001$), with a significant linear downward trend over time ($p = 0.001$). The same pattern occurred for the Impact of Event Scale ($p < 0.001$), and the Beck Depression Inventory ($p = 0.002$). Physical injury, medical care or loss of loved ones at the time of disaster, were not associated with higher total SCL-90 scores or somatic sub-scores. Both duration of threat to life and female sex were correlated with all measured outcome parameters.

Conclusions

Exposure to the 2004 Asian tsunami had a significant short and long-term impact on health complaints in a group of repatriated Dutch tsunami victims. Despite a clear trend to recovery over 4 years, 22% still reported high psychological and physical distress 4 years post-disaster. Duration of danger to life and female sex were associated with more physical and mental health complaints. In this study neither disaster-related injury nor loss of loved ones resulted in worse outcomes.

Introduction

Disasters are traumatic events that may result in a wide range of physical and mental health consequences. In addition to despair and grief, as well as sadness and anger in case of lost or missing loved ones, injured survivors of disaster typically face challenges in the immediate aftermath of disaster, such as danger to life, injury, displacement from home, transportation, and seeking rapid and adequate medical help. A proportion of victims will present in a hospital for disaster-related physical injury and receive medical care. It has been indicated that those who are physically injured would eventually be in worse physical and mental shape when compared to a non-injured group.[1-3] The same could be true for the loss of loved ones. However, the predictive value of being wounded, needing medical care or losing loved ones on the long-term mental and physical outcome has not often been studied. Studies on post-disaster health effects typically focus on posttraumatic stress disorder (PTSD). This is the most commonly studied psychopathologic entity in the aftermath of disasters.[3-5] Millions of people were affected by the 2004 Asian tsunami and an estimated 227,898 people died.[6] Particular to this disaster was that many tourists were visiting the area. Most of them returned to their unaffected home environment. The impact of the 2004 Asian tsunami on these repatriated victims has been studied in survivors living in Scandinavian countries, however, this also mainly focussed on PTSD.[7-9]

Many post disaster studies emphasise the need for long-term follow-up to eventually betterteh understand trajectories of illness and recovery and identify situational and personal risk factors for long-term complaints.[3, 5, 10]

In a previous prospective follow-up study in a small cohort of injured survivors of the 2004 tsunami we demonstrated that the long-term impact of exposure to the Asian tsunami on physical and emotional complaints, as well as on health care use and daily activities was considerable.[11] The current study presents new data on physical and mental effects collected in a larger cohort of Dutch survivors of the 2004 tsunami over a 4 year time span. Our goal was to examine the impact of exposure to this disaster on both short (first months), middle, and long-term (4 years) health complaints in an affected population. We were interested in finding predictors of negative health outcome and, in particular, the predictive value of disaster-related factors (injury, loss of loved ones, danger to life). Furthermore, we were interested in the differential effect of physical injury and the physical burden of experiencing both physical and psychological trauma. Awareness of and insight into the impact of disasters on health complaints in the short and long term could provide opportunities for surveillance and early treatment. It could contribute to the recognition of eventual late health consequences.

Methods

Study design and participants

The registered count of Dutch visitors that were in the affected area is 500, of whom 36 died during the disaster. In collecting data from this Dutch affected population, we employed a novel approach through a web-based service that contained an open, online survey on the physical and mental health status of survivors. In January 2005, two weeks after the disaster, a web service (www.tisei.org) was launched to foster (community) support in the aftermath of the disaster.[12, 13] The website was unique in combining several functionalities aimed at empowerment of survivors: 1. information portal with news feeds selected for the target population, 2. online survey with self-assessment, 3. open forum and 4. e-consultation service.

In the long run, the web portal also served as a memorial archive for anniversary meetings and follow-up incentives. We reported elsewhere on the traffic that the web-portal generated and the usability of the web-service.[12, 13] This report focuses on the results of the 4 year follow-up survey of the Dutch population.

Patient recruitment for the survey was performed by an announcement on the web site and postings in national and local media. A link to the web portal was provided on the site of the International Society for Traumatic Stress Studies. Over a 4 year time span, between January 2005 and January 2009, the survey was available by registration to the survivors of the disaster. We collected 175 survey lists from 144 respondents. We grouped the assessments in 4 time periods (0-3 months, 4-6 months, 7-30 months and 31-48 months after the disaster). Subjects needed to be at least 18 years old, in order to participate. Prior to participating in the survey, participants gave informed consent and registered to receive a password by email to enter the survey. The Institutional Review Board of the University Medical Centre Utrecht and the MIH approved the study after an expedited review. All data were stored anonymously in accordance with European law. The self-assessment/survey was accompanied by an optional e-consult service for participant safety as focussing on details of these topics could potentially exacerbate distress in an already distressed participant.(14) In the Dutch portal all questionnaires that were used were translated versions into Dutch (Babel Translations, Utrecht).

Measurements

The survey consisted of nine questionnaires, with a total of 271 questions. These were divided into 6-34 items per viewing page, with the exception of one section that contained 90 questions. The number of screens (viewing pages) was 14. Respondents were able to review and change their answers using a back button.

Demographics and disaster-related factors

The survey started with questions about details of the disaster experience and situational information (e.g. type of trauma, closeness to the sea, endangerment of life, loss of loved ones). Duration of danger to life was qualified in four categories as: none, minutes, half hour-hours, day(s). These questionnaires also contained questions about physical trauma to the participant, as well as their relatives, including eventual death. When appropriate, questions were accompanied by space for free text.

Disaster-related questions were followed by questions on socio-demographic details. The following socio-demographic and lifestyle characteristics were measured: sex, age, marital status (single/with partner), children, living situation (with parents/alone/with partner/other), employment status (having a job or studying) and education level. The latter was divided into 3 groups; low for no formal education, elementary school, lower vocational education or lower general secondary education, high education level was college or university, and middle consisted of the intermediate group. Furthermore, information regarding medical and mental health status, as well as, history was gathered together with medication, smoking and alcohol-use.

Psychological and physical distress

The Symptom Checklist 90 (SCL-90-R)[15, 16] was used to assess physical and psychological symptoms. This checklist contains 90 questions with a 5-point rating scale on physical and emotional complaints. Respondents were asked to rate how much discomfort each symptom has caused them in the past week (including today), ranging from "not at all" (score 1) to "extremely" (score 5). Outcome scores were divided into 9 symptom subscales or dimensions: agoraphobia (AGO, range 7-35), anxiety (ANX, range 10-50), depression (DEP, range 16-80), somatisation (SOM, range 12-60), insufficient thinking and handling (IN, range 9-45), distrust and interpersonal sensitivity (SEN, range 18-90), hostility (HOS, range 6-30), sleeping disorders (SLE, range 3-15), and a rest subscale (OVER, range 9-45). The total score (SCL-90-TOT, range 90-450) was calculated by adding the scores of the subscales. This quantifies the general level of symptomatic psychological and physical distress. The Dutch SCL-90 has shown to have good psychometric properties.[17] Dimension scores and the total SCL90 scores were compared to the established references for the general Dutch population (Norm group II, n = 2368), adjusted for sex.[16]

Impact of the event

The Impact of Events Scale (IES)[18, 19] was used to assess the degree of intrusions and avoidance reactions related to the traumatic event, in a window of the previous seven days. The Dutch version consists of 15 questions with a 4-point

Likert scale on frequency and intensity of symptoms (none=0, rarely=1, sometimes=3, often=5). An overall score (range 0-75) is calculated by adding the scores on the individual items. The Dutch IES is well validated.[19] A cut off score of >25 was used to identify victims with relatively severe intrusion and avoidance symptoms.[20]

Depression

For assessment of depressive symptoms the Beck Depression Inventory (BDI-II)[21] was used, a 21-question multiple-choice self-report inventory that quantifies the severity of depression. Scores range from 'no symptoms' to 'very severe' symptoms, with a maximum of 3 points for each question. The scores range from 0 to 63. A score of 0-13 is regarded as minimal symptoms of depression, 14-19 mild, 20-28 moderate severe, and 29-63 marked as severe depression.[21, 22] Questions are divided into 3 dimensions or subscales (cognitive, somatic and affective). The BDI has good psychometric properties.[23]

Statistical analysis

The interval between the disaster and the moment of entry in the survey varied substantially among respondents. Therefore, it was chosen to stratify the data into four post-disaster time periods where the first two were relatively short (3 months) and the last two covered a longer time span (24 and 18 months respectively). The time periods were labelled as months post-disaster: 0-3 months (T1), 4-6 months (T2), 7-30 months (T3) and 31-48 months (T4). Time period (four nominal categories) and gender (male/female) were dealt with as stratification factors in the statistical analyses.

Raw summary statistics (mean and SD) of the continuous outcome variables SCL-90 (total scale and subscales), IES and BDI (total scales) were presented by time period. Also raw relative frequency distributions were presented per time period after a relevant categorization of those outcome variables.

In order to account for repeated assessments per participant the continuous outcome variables were analysed using linear mixed modelling. A compound symmetry structure was imposed on the (co)variances of the repeated measures. A first simple mixed model analysis only involved time period and gender as explanatory factors in order to present gender-adjusted means and their confidence limits; also a test against trend in time was carried out using this simple model.

In a more elaborate mixed model analysis the following explanatory demographic and outcome and disease-related factors were entered simultaneously in the linear mixed model, along with time period and gender: age (numeric trend of four ordinal levels), education (numeric trend of three ordinal levels), employment (yes/no), marital status (single/partner), physical history (yes/no), psychological history (yes/no), physical disaster-related injury (yes/no), medical care (yes/no), loss of loved ones (yes/no) and duration of danger to life (numeric trend of four ordinal levels). The effects of the last four explanatory variables were also tested one-by-one against modification by time period at the more stringent significance level of 0.01 than the level of 0.05 used otherwise.

Deviations in observed SCL-90 scales in male and female respondents from the corresponding, assumedly fixed, means of the Dutch normal reference population[16] were also analysed using linear mixed modelling with time period (T1-T4) as an explanatory factor.

Internal consistency of the SCL-DEP and BDI-II scores, both testing for depressive symptoms, was quantified by using the partial correlation coefficient with adjustment for time period and gender.

All calculations were performed with the PASW/SPSS® statistics 18.0 software (IBM®).

Results

Respondents and trauma

Over 4 years 175 surveys were completed, which could be anonymously linked to 144 unique respondents. Of these 144 respondents, 120 respondents completed the survey assessment once, 18 respondents filled in two assessments at different times, 5 respondents participated in three assessments and 1 respondent completed four assessments. The completion rate of all questionnaires of the entire survey was 93%. Sixty-seven (38%) of the survey lists were filled in by 59 males and 108 (62%) surveys by 85 females. The majority of the respondents fell within the age range 25-60 years. Nine respondents were younger and two were older than 60 years. Between the different time periods there were no significant differences in age-distribution and gender. The education level was high and 90% were employed. Also, the group was relatively healthy. Of all respondents 17% were taking medication, and 28% were smokers. For socio-demographic details of the respondents *see Table 1*. Of the respondents 74% were on vacation, 6% were in the area for work at the time of the tsunami. The respondents sojourned in Thailand (81), Sri Lanka (43), India (18) and Indonesia (2). Only 13 (9%) of the respondents were travelling alone, the rest were either with family or friends.

Table 1. Socio demographic details of all 144 participants

Gender	males	59	41%
	females	85	59%
Age group	18-25	9	6%
	25-40	74	51%
	40-60	59	41%
	> 60	2	1%
Marital status	single	29	20%
	married	115	80%
Children	yes	53	37%
	no	91	63%
Educational level	low	8	7%
	middle	42	30%
	high (college or university degree)	90	63%
	unavailable	4	
Employment	no work/study	15	10%
	work/study	129	90%
Health history (before disaster)	physical history	29	20%
	history psych/emotional complaints	45	31%
	medication	25	17%
	smoking	41	28%
	alcohol	88	61%

When asked about disaster specific experiences, one third of the respondents reported that they had seen the sea pulling back, and only one third were not on the beach during the event. Respondents reported they were pulled by the wave (32), ran for it (35), or had been hiding on a roof (6). Almost half of the respondents (40%) had been some time under water. Some of the most frequent reported experiences at the time of the disaster included the roaring noise of the wave, screaming people, seeing collapsing buildings, seeing dead people, panic, and the feeling that you could die any moment. Seventy four percent of the respondents reported negative experiences and 86 % also reported positive experiences, such as the resiliency of the Thai people, brotherhood, and hospitality.

Forty-nine of the respondents (34%) reported they had been wounded as a result of the tsunami, and 46 (32%) needed medical care. Thirty-one (22%) of the respondents had a loved one that was killed in the tsunami. The majority of the respondents had experienced danger to life, ranging from minutes to hours and for 13 victims this lasted more than a day. A minority of 27 respondents (20%) had not been in danger of life during the disaster. For details and distribution of disaster-related trauma factors in the time periods *see Table 2*.

Table 2. Disaster-related factors: injury, situational factors and representation in the time periods

	TOTAL GROUP		TOTAL GROUP		T1 (%) 0-3 months		T2 (%) 4-6 months		T3 (%) 7-30 months		T4 (%) >30months	
	144 participants		175 lists		59		28		51		37	
Injured	49	34%	66	38%	16	27%	11	39%	23	45%	16	43%
Medical care	46	32%	59	34%	13	22%	10	36%	21	41%	15	41%
Missing/died loved ones	31	22%	38	22%	11	19%	8	29%	11	22%	8	22%
Danger to life												
None	27	20%	32	20%	13	22%	4	16%	6	13%	9	32%
Minutes	50	38%	63	40%	18	31%	13	52%	21	45%	11	39%
1/2 hour-hour(s)	43	30%	49	31%	21	36%	7	28%	14	30%	7	25%
Day(s)	13	10%	14	9%	6	10%	1	4%	6	13%	1	4%
unavailable	11		17		1		3		4		9	

General distress; physical and psychological symptoms (SCL-90)

For males, the mean overall SCL-90-TOT score was 142.8 (SD 53.0). For female respondents the mean was 149.3 (SD 54.2). Across the whole group, in any time period, the mean SCL-90 of the study population was significantly higher than that in the reference population[16], accounting for sex ($p<0.0005$).

There were 12 respondents who caused 12 missing values on the SCL-90. Their profiles did not differ significantly in age, gender or exposure from the rest of the group.

Raw summary statistics of the SCL-90, IES and BDI (175 lists) and the representation in the different time periods can be found in *Table 3*. *Table 5* shows the percentages of participants with high scores across the time periods, including SCL-90 subscales.

Table 3. Mean SCL 90, IES and BDI scores across the time periods (raw summary statistics of all 175 lists)

	TOTAL		T1 0-3 months		T2 4-6 months		T3 7-30 months		T4 31-48 months	
	175		59		28		51		37	
	Mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
SCL-90-TOT										
males	142.8	53.0	160.2	68.1	126.1	35.5	142.7	50.5	130.6	34.2
females	149.3	54.2	165.9	61.1	170.7	56.1	132.0	37.4	135.8	50.4
unavailable	12		3		3		5		1	
IES	30.1	15.9	36.1	15.1	30.3	17.5	38.9	15.5	21.6	12.7
unavailable	5		1		0		1		3	
BDI	11.6	8.6	14.8	9.3	10.2	7.4	10.1	8.0	9.3	8.0
unavailable	12		3		3		4		2	

Table 4. Estimated mean SCL-90-TOT, IES and BDI by time period and gender using linear mixed modelling

	SCL-90-TOT		IES		BDI	
	Estimate	(95% CI)	Estimate	(95% CI)	Estimate	(95% CI)
Time period 1 male	159.7	(141.7-177.7)	35.0	(28.5- 41.4)	14.1	(10.7- 17.4)
Time period 1 female	163.7	(150.3-177.2)	37.5	(32.7- 42.3)	16.0	(13.5- 18.6)
Time period 2 male	140.1	(118.1-162.1)	29.8	(22.1- 37.6)	10.0	(6.0- 14.0)
Time period 2 female	145.6	(119.9-171.4)	28.5	(20.4- 36.6)	11.6	(6.7- 16.4)
Time period 3 male	135.9	(118.2-153.5)	27.4	(21.2- 33.7)	11.2	(8.0- 14.5)
Time period 3 female	132.3	(114.3-150.4)	28.7	(23.1 34.4)	9.6	(6.5- 12.7)
Time period 4 male	130.1	(104.8-155.3)	19.1	(7.4- 30.8)	7.6	(2.5- 12.7)
Time period 4 female	145.3	(131.8-158.7)	24.4	(19.0- 29.8)	9.9	(7.2- 12.6)

Estimated mean SCL-90-TOT scores and their 95 % confidence intervals by time period and gender resulting from linear mixed modelling are presented in *Table 4*. The pooled within-SD equals 52.4. Average significant downward trends with time period were found in males and females: 9.9 points per time period in males (95 % CI: –18.3 to –1.5; p = 0.022) and 6.9 points per time period in females (95 % CI: –11.8 to –2.0; p = 0.007).

Table 5. Physical complaints, high general distress (SCL-90), high avoidance and intrusion reactions (IES), and degree of depressive complaints (categorical BDI scores) (raw summary frequencies of all 175 lists) by time period.

	TOTAL		T1 0-3 months		T2 4-6 months		T3 7-30 months		T4 > 30months	
Total 175 lists	TOTAL		59		28		51		37	
Physical complaints	81	46%	30	*51%*	12	43%	25	49%	14	38%
High general distress (SCL-90, >mean+1 SD)										
TOT	52	*32%*	23	*41%*	10	*40%*	11	*24%*	8	*22%*
SLA	51	*31%*	25	*45%*	8	*32%*	14	*30%*	4	*11%*
HOS	*36*	*22%*	13	*23%*	9	*36%*	8	*17%*	6	*17%*
SEN	28	*17%*	11	*20%*	6	*24%*	6	*13%*	5	*14%*
IN	62	*38%*	30	*54%*	10	*40%*	12	*26%*	10	*28%*
SOM	38	*23%*	20	*36%*	4	*16%*	8	*17%*	6	*17%*
DEP	62	*38%*	28	50%	11	44%	15	33%	8	22%
ANG	47	*29%*	21	*38%*	8	*32%*	11	*24%*	7	*19%*
AGO	64	*39%*	27	*48%*	9	*36%*	16	*35%*	12	*33%*
Unavailable	12		3		3		5		1	
Severe avoidance and intrusion (IES)										
IES>25	170	57%	43	74%	14	50%	28	56%	12	35%
Unavailable	5		1		0		1		3	
Depressive complaints (BDI-II)										
Minimal (0-13)	104	*64%*	30	*54%*	15	*60%*	33	*70%*	26	*74%*
Mild (14-19)	28	*17%*	11	*20%*	6	*24%*	6	*13%*	5	*14%*
Moderate severe(20-28)	23	*14%*	8	*14%*	4	*16%*	8	*17%*	3	9%
Severe (29-63)	8	*5%*	7	*13%*	0	*0%*	0	*0%*	1	*3%*
Unavailable	12		3		3		4		2	

SCL-90 scores are defined as high when they exceed the sex specific mean + 1 standard deviation taken from the reference population.
A cut-off score of the IES of >25 is used to identify victims with relatively severe intrusion and avoidance symptoms.[18]
The BDI is divided in four categories of severity of depressive symptoms.[19, 20]

Of the demographics and disaster-related factors, only the duration of danger to life had a significantly negative effect on SCL-90-TOT: there is an average increase of 8.3 points (SE 3.9) points in SCL-90-TOT per category of longer duration. None of the other factors had a significant effect on SCL-90-TOT. There was no indication that the effect of longer duration of danger was modified by time period (p = 0.12). None of the other three factors that were tested against effect-modification by time period reached significance.

Of the SCL-subscales significant main effects of the demographics and disaster-related factors were only seen on SCL-HOS (hostility) and SCL-SLE (sleep) subscales. Respondents who had received medical care had a 2.60 points (SE 0.79; $p = 0.002$) higher score on SCL-HOS than respondents without medical care, the effect of which was not significantly modified by time period ($p = 0.42$). A longer duration of danger resulted in a 0.63 points (SE 0.31; $p = 0.044$) higher score on SCL-SLE (sleep) per category of longer duration. No significant modification of this effect by time period was seen ($p = 0.11$).
All SCL-subscales showed a downward trend with time period, although not all subscales reached significance in this respect. On none of the SCL-subscales could a significant effect of gender be observed.
Somatic complaints (SCL-SOM) were only significantly higher than the reference population in the first time period T1 (difference of +4.6 points: $p<0.0005$: 95% CI 2.5-6.3). This was not observed in later time periods. The entire group (not stratified in time periods), as a whole, also scored higher on the SCL-SOM than the reference (+2.01 points, $p=0.003$: 95% CI (0.7-3.4) and the somatic subscale also showed a significant linear downward trend ($p =0.002$).

Avoidance and intrusion (IES)

Estimated mean IES-scores and their 95 % confidence intervals by time period and gender resulting from linear mixed modelling are presented in *Table 4*. Five respondents had a missing IES-list. The mean IES was 30.1 (SD 15.9). The pooled within-SD equalled 15.5. Significant downward trend effects with time period (T1 to T4) were found in males and females: on average 4.3 points per time period in males (95 % CI: –7.9 to –0.7; $p = 0.018$) and also 4.3 points per time period in females (95 % CI: –6.5 to –2.1; $p < 0.0005$).
Singles scored 7.7 points (SE 3.5; $p = 0.032$) higher on IES than those with a partner. We found an average increase of 3.0 points (SE 1.5; $p = 0.042$) in IES per category the longer the duration of danger to life. None of the other disaster-related factors had a significant effect on IES. Also no significant effect-modifications by time period at the 0.01-level were found. Both time period (as categorical variable) and gender did not have significant main effects on IES (respective p-values 0.096 and 0.30).

Depressive complaints (BDI)

Estimated mean BDI-scores and their 95 % confidence intervals by time period and gender resulting from linear mixed modelling are presented in *Table 4*. The pooled within-SD equalled 8.5. Significant downward trends with time period were found in males and females: on average 1.7 points per time period in males (95 % CI: –3.4 to –0.0; $p = 0.048$) and 2.3 points per time period in females (95 % CI: –3.2 to –1.1; $p < 0.0005$).

Some disease and injury related factors had a significant effect on BDI. Physical injury resulted in a 3.95 points (SE 1.74; $p = 0.032$) higher BDI-score. Having received medical care resulted in a 3.93 points (SE 1.79; $p = 0.044$) lower BDI-score. Per category higher duration of danger gave a 1.58 point (SE 0.71; $p = 0.035$) higher BDI-score.
We found no indication that these effects on BDI were modified by time period (respective p-values: 0.45, 0.65 and 0.071). Time period had a significant main effect on BDI ($p = 0.004$), but gender did not ($p = 0.99$).
The partial correlation between the SCL-DEP and the BDI, corrected for time period and gender, was 0.85, which indicates a good internal consistency of the data.

Discussion

This is one of the first studies that use a web portal to collect data from a community to assess the long-term impact of a natural disaster on health complaints over a time span of 4 years. The data show that tourists that are exposed to a major natural disaster and repatriated to their unaffected home environments have elevated scores on somatic, as well as, psychological symptoms. Remarkably, over time there is a significant drop across all symptom scales, but all scores remain elevated in comparison to norm scores in the long run.[16, 20] With reference to the initial hypothesis, it could not be demonstrated that disaster-related injury or death of loved ones correlated with worse outcome scores or with more somatisation. Duration of danger to life is a predictor though for all health-related outcome scores at all time points. Furthermore, when comparing gender outcomes, it appears that women have higher scores than males.
These data are remarkably similar to a recent postal survey among disaster-exposed, repatriated Scandinavian tourists. Participants were categorised according to disaster exposure: danger exposed (caught by waves), non-danger exposed (other disaster-related stressors) and non-exposed. It appeared that danger exposed subjects reported more post-traumatic stress than non-danger exposed individuals and symptoms attenuated by 14 months follow-up.[7] In their sample, female gender and low education predicted higher levels of symptoms. Yet, based on a smaller Norwegian sample the authors reported that recall amplification of perceived life threat needed to be accounted for. Recalled life-threat intensity increased from 6 to 24 months which questioned diagnostic validity of PTSD symptom improvement.[24] Recall amplification was associated with a lack of PTSD symptom improvement. This does not apply to the sample in this study as, while remaining high, health symptoms improved over time.

In this dataset a clear trajectory of recovery is visible. Over a time span over 4 years the affected group as a whole demonstrated an attenuation of reported physical and mental health complaints. This was observed with all outcome parameters (IES, BDI, SCL-90). Evidence of a general decline of incidence of PTSD can also be found in the literature[3], but is not so well documented for overall psychological and physical well-being as measured with the SCL-90. Follow-up for several years is scarce and there are not many long-term post-disaster follow up studies.[3] Even though symptoms attenuated, four years after the tsunami 22% of all respondents still reported high levels of general distress, and 12% were moderately to severely depressed. On intrusions and avoidance reactions 35% of the respondents in the last time period scored higher than the cut off for severity.

The hypothesis was that the health complaints and trajectory of recovery would be related to being wounded, the need of receiving medical care at the time of the disaster or the loss of loved ones, in accordance with the literature on PTSD after disasters, where physical injury and loss of a close family member are indicated as risk factors for the development of PTSD.[3] This could not be confirmed for either of these parameters on outcomes of mental and physical distress, somatic subscale, impact of events and depression. A significant number of respondents (34%) reported that they had been wounded as a result of the tsunami; a similar sized group needed medical care for their injuries. They fell into a category that was labelled as disaster-related injuries (DRI), varying from wounds and fractures to concussion and lung injury. Yet, none of these contributed to a worse outcome on short and long-term health assessment. In an earlier study similar findings were reported in a small group of injured victims that were medically repatriated because of their injuries. 25% of this cohort rated their health, 4 years after the disaster, as worse than before and a third of the group still felt hindered in their daily activities 4 years post-disaster.[11] Surprisingly however, DRI failed to demonstrate lower quality of life scores at 6 months and 4 years in comparison to a reference population.[11, 25, 26]

In this study female gender appears to be a risk factor for worse outcomes of physical and mental health. This is consistent with the literature that indicates female gender as a risk factor for PTSD.[5]

There are only a few studies on the influence of physical injury on general psychological and physical status in disaster patients and therefore comparison with the current data is difficult. Although PTSD study outcomes will not be the same as outcomes in studies on general physical and psychological distress, they could give indications about factors that might affect the SCL90. The rates of post-disaster PTSD should be used with caution as they are identified in different studies by using different diagnostic criteria and methodological differences.[27] A recent study of Thai tsunami victims by Thavichachart et al described factors associated with PTSD. They reported that "injury" and "being in the direct affected area" was found to be correlated with psychological factors.[28] Although they used the SCL-90 in their survey, their outcomes for this parameter are not available in their report for comparison with the results of this study. Although some earlier studies indicated that injury[1,3] and loss of loved ones could be regarded as factors of influence on development of PTSD[3, 28], in this sample no relationship was found between these factors and general psychological and physical wellbeing as measured by the SCL-90.

While the body of research has focused on PTSD and other psychiatric disorders among disaster victims, some studies also document other symptoms, e.g. somatic complaints.[29] In a study in Puerto Rico, exposure to a natural disaster was related to a high prevalence of medically unexplained physical symptoms, particularly gastrointestinal and pseudoneurological. This and other studies are suggestive of clinically important new somatisation after disasters.[29, 30] The results from this study also show significantly elevated scores on the somatic subscale of the SCL-90, predominantly caused by high somatic complaints in the acute phase. In this study DRI among these victims did not result in higher scores on the somatisation dimension of the SCL-90. Van den Berg et al. showed that medically unexplained symptoms are common in survivors of disasters and are more prevalent in those affected by disasters compared with the general population.[29] In some studies medically unexplained symptoms had been measured by the somatisation scale of the SCL90.[31]

One important limitation of the interpretation of this dimension must be highlighted. Although this scale was designed to assess somatic complaints, the diagnosis of somatisation (disorder) would require the ability to rule out medically-based explanations of the reported symptoms[30], and this was not done in this study.

Thirty-six Dutch tourists did not survive the tsunami. Of all respondents, 22% were related to one of this group of 36. Looking at the impact of the loss of loved ones on physical and mental health, no significant effect could be attributed to this factor. The group that was affected by this loss did not demonstrate a significant difference in outcome scores in comparison to the group that did not suffer from such a loss.

Duration of danger to life, however, proved to be a good predictor of outcome while actual injury was not. In many PTSD studies "the degree of exposure to the disaster" is associated with the likelihood of PTSD[5], which is highest with direct exposure to the disaster.[3] In a systematic review by Neria et al this is mentioned as the most consistently documented determinant of the risk of PTSD.[3] Exposure is measured differently in several studies and therefore difficult to compare. Mostly it is defined by distance to the scene or observed "things" rather than in (duration of) endangerment to one's own life. In this study, injury (so in direct proximity to disaster) proved not to be correlated to PTSD, but danger to life was. The majority of the respondents (80%) had experienced danger to life, ranging from minutes to hours and in some this lasted more than a day. This factor appeared to have strong predictive value for non-specific reported health complaints. There was no specific cluster of health complaints that could be identified to account for this. In a study after Turkish earthquakes by Basoglu et al. fear of danger to life was also found to be a determinant.[32] This could indicate that fear for one's own life could be the determinant factor in exposure that causes higher scores in people that were close the disaster.

There are some limitations to the current study that have to be taken into account. First, the sample studied is a self-selected sample of convenience from the total affected Dutch population. This is a recognised potential limitation of the disaster literature.[1] It was not possible, for obvious reasons, to compare the responding tsunami survivors participating in the online survey with a non-responding group of survivors. Selective non-response based on socio-economic and psychosocial variables influencing the result can therefore not be ruled out. As in almost every survey after a disaster, participants form a volunteer sample rather than probability sample.[33] Yet, given the fact that at the time of the tsunami approximately 500 Dutch people were present in the disaster areas, a considerable part of the target population was reached to participate in the survey. Notwithstanding that this is a study with a sample of convenience the numbers are large enough to demonstrate a trajectory of recovery. It is known from other studies that these trajectories can be long, however little empirical data exist. This study adds to this body of evidence over a considerable time-span. Selective attrition could even have been minimised by the use of a web portal that also contained a forum, information and an online survey, as this also attracted participants that did not seek professional help, in contrast to interview studies among (self) referred patients.[34, 35] As for reliability of Internet-based questionnaires, several studies have shown that sensitive topics, such as psychiatric symptoms are more likely to be reported in self-reported assessments than in interview-based assessments and computerized forms are a good alternative. Although not confirmed in all studies[36], web-based data collection, therefore, has a potential to reduce social desirability bias.[37-39]

Second, due to the method of data collection that was used, the strict anonymisation procedure, as well as, changes of (email) addresses, independent entries over time could not automatically be matched to the same participant and had to be matched manually, and opportunities to gather more longitudinal follow-up data were hindered. Further developed current techniques should be able to ease this issue in future online surveys.

Third, pre-disaster measurements of this population were not available and, therefore, there is no prospective data as to their pre-existent psychiatric morbidity. Introversion, neuroticism, and a history or family history of psychiatric disorder are known premorbidity factors significantly associated with the development of chronic mental health problems after natural disaster.[5,40] Thirty one percent reported previous psychological or emotional problems in the post-disaster self-report. Since this group was mostly in the area for vacation or business it may be assumed that they were a resilient group.
Last, studies of responses to disaster have a necessarily observational and post-event nature, which makes it difficult to identify true causal relationships between exposure and observed outcomes. Although this survey will therefore not provide causal incidence, data, empirical evidence and qualitative research on the impact and adjustment process after disaster exposure will aid clinicians in designing interventions for individuals coping with negative outcome.[41] For in depth understanding of experiences of particular individuals or groups, qualitative aspects are as important as quantitative.
Using a web service for long-term cross sectional research among subjects after exposure to a natural disaster proved feasible. Emerging Web 2.0 technologies with social media and applications are providing a new way for web users and health workers in information sharing and knowledge dissemination, as well as, research opportunities. Internet social networking tools, being immediate, two-way and large scale, can be successfully utilised as a solution in emergency response during disasters[42], as well as for patient empowerment and long-term follow-up of survivors.[13] With greatly improved technology, use of social media, long-term longitudinal research through an Internet survey should be feasible. The identification of individuals at risk for health complaints following a disaster may help organisations decrease both human and economic costs. Awareness of and insight into the impact of disasters on health complaints in the short and long term can provide opportunities for surveillance and early treatment.

In conclusion, even though there is a group-wise trend of recovery on physical and mental health over a 4 year time period, long term high psychological and physical distress was seen in people exposed to a natural disaster. Despite significant amelioration in the timeperiods, 1 out of 5 participants reported significant persistent somatic complaints, while 1 out of 3 reported significant avoidance and intrusion scores 4 years after exposure. One out of 7 participants still reported moderate to severe depression scores. For a quick assessment of the impact on all domains the duration of danger to life served as a predictor for all health related outcome measures. Disaster-related injury and loss of loved ones, however, did not necessarily result in worse outcomes for short and long-term health complaints. The data from this study highlight that the long-term impacts of mass disaster merit a joint care approach since they impact both physical and mental health. This requires transdisciplinary care and emphasises that the field of disaster medicine should embrace both domains of expertise.

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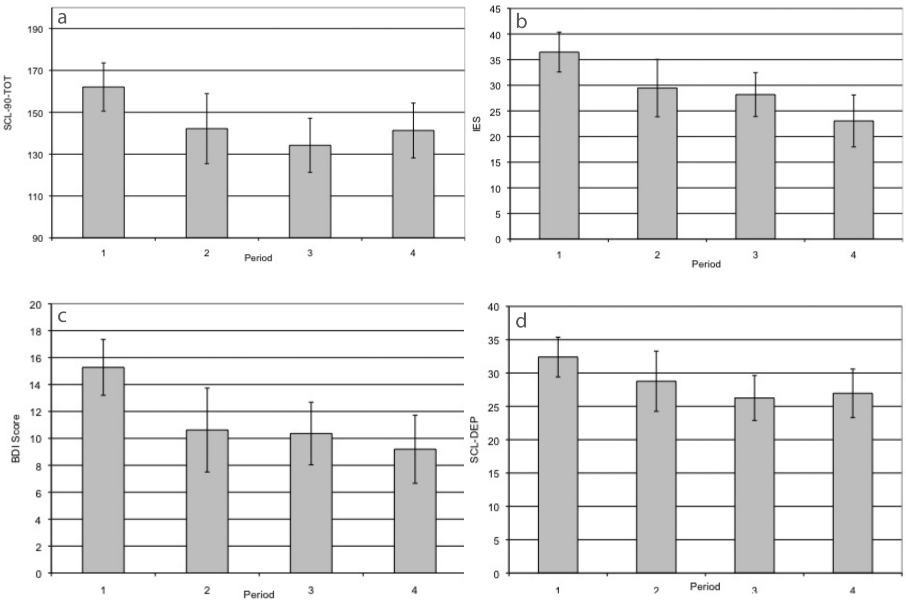
Appendix



Gender-adjusted mean SCL-90, IES, BDI en SCL-DEP scores with 95% CI's estimated using linear mixed modelling. There is a significant downward trend of the gender-adjusted means a) P = 0.001, b) P < 0.0005, c) P = 0.002 and d) P = 0.004 test against trend.

Chapter 9

Summary
Discussion and Conclusions

Summary

Providing optimal care for a sudden, unexpected large amount of victims from a disaster or major incident is challenging. It requires an approach different from regular traumacare.[1, 2] The goal of treatment in this setting must change from the greatest good for each individual to the greatest good for the greatest number. The population as a whole, rather than the individual, should be the focus of management.[3, 4] As disasters and major incidents are not part of daily medical practice, preparation, cooperation, training and evaluation are essential to improve outcome.

This thesis focuses on medical preparedness, care and follow-up for victims of a disaster or major incident, and explores new opportunities for improvement of disaster relief using the Internet as a supportive tool.

Chapter 2 describes the development of the Major Incident Hospital (MIH) as a permanent, reserved facility to offer acute, structured care for groups of casualties from a major incident or disaster. The MIH is an internationally unparalleled facility, which was created by the cooperation between a military hospital, an academic hospital, a trauma center, and the National Poison Information Center (NVIC). The MIH is a "dormant hospital" located in an 8.000m2 underground, nuclear-proof facility under the University Medical Center Utrecht (UMCU), The Netherlands. The hospital consists of a triage and treatment area (35 beds), intensive-care unit (12), medium-care unit (30) and two low-care departments (200). There are four quarantine boxes, three operation rooms with recovery and a radiology department for conventional and ultrasound radiology. The MIH has its own energy supply, computerization and medical gas supplies. The stand-alone air conditioning system enables centralized quarantine care for patients with contagious conditions such as SARS, smallpox, or contamination with chemical or biological agents.
An Emergency Response Protocol is used to direct expeditious staffing, start-up and relief. This protocol enables the normally dormant hospital to admit up to 100 patients after a start-up time of only 15 minutes.
The aim of the MIH is to offer relief in five scenarios:

1. war or threat of war, crisis or conflict management in which large numbers of casualties need care;
2. accidents abroad involving Dutch citizens, either civilian or military, who need repatriation and medical care;

3. specific incidents, attacks or large-scale accidents in The Netherlands that exceed the capacities of regular care facilities;
4. international medical assistance from the Dutch government concerning the treatment of foreign victims;
5. quarantine care for patients with special infectious and highly contagious diseases, such as SARS (added since 2003).

Due to totally separated facilities, patients from scenario 1, 2 and 3 can be cared for in (MRSA) quarantine.
At the MIH, the exception has become the core business. Preparation for disasters and large-scale emergency care is a daily occupation. Focus points are: patient flow and triage, registration, communication, evaluation/research and training. When the MIH is not in use for a major incident, there is time to address training and research.

Research and evaluation of past incidents provide knowledge for preparedness and response to future unknown incidents. This has proven to be essential for further improvements.[4] In **Chapter 3** the implemented organisation and the use of the MIH along the five scenarios for activation, since its foundation in 1991, are evaluated. All 34 deployments were analysed according to the points of the Protocol for Reports from Major Accidents and Disasters.[5]
The MIH demonstrated to be able to provide adequate, group-wise emergency care in case of the first four scenarios. Patient populations consisted of military (29) as well as civilian victims of major incidents and disasters, both national (260) and international (226). Furthermore, 4 deployments took place to offer care for foreign major incident victims (44). The scenario of quarantine care for special infectious or highly contagious diseases has not occurred up until now.
Triage played a critical role in the set-up of the hospital and is instrumental to the MIH's objective; to deliver greatest good for the greatest number rather than direct extensive treatment of each individual. The concept of minimal acceptable care is applied in every echelon of care until casualty influx has ceased.
Strong points of the MIH are: preparedness and availability of a dedicated facility; personnel trained in (disaster)triage through successive echelons of care; and prearranged cooperation with partners in major incident relief.
Group-wise treatment was advantageous for overview, logistics, registration, quarantine, emotional support and (pre)arrangements for family, media and security.

The fact that the hospital is strictly reserved for this type of care guarantees availability and, thereby, minimizes impact on regular care.
In the evaluation of the 34 deployments, (MRSA) quarantine care has again proven necessary in several instances for repatriated patients, but also in cases where the MIH was not used for relief.
Evaluation, research and training resulted in several adaptations and developments to improve preparedness. An example of a new development is the Patient Barcode Registration system (PBR) with EAN barcodes. The PBR facilitates overview, improves medical and logistic handling, and is easy to use without need for extensive additional training. It showed 25% less inaccuracies when compared to handwritten medical charts.[6, 7]
The evaluation of all MIH deployments resulted in five concluding recommendations:

1. improvement of embedding of the MIH in regional and national procedures
2. continued dedicated time and staff for training, research and development
3. improvement of nuclear/biological/chemical decontamination facilities and preparedness
4. implementation of standardized scoring systems
5. expansion of registration systems to the pre-hospital setting.

In major incident relief, the partners-in-care typically experience lack of overview of victims and difficulties in sharing information. To prevent these problems, an online Victim Tracking and Tracing System (ViTTS) was developed. This is described in **Chapter 4**. The ViTTS is based on a wireless network generated by routers on ambulances, with direct online registration of victims and their triage-data through barcode injury cards. The central data bus connects the different systems of the disaster relief partners (medical chain, fire department, (local) government, police, Red Cross).
The system was successfully tested for feasibility and usability during disaster drills. The conjured local radio-network of hotspots with mobile routers and connection over GPRS to the central database worked well. ViTTS produced accurately stored data, on-time availability, and a real-time overview of the victims (quantity, seriousness of injury, location).
The ViTTS provides a system for early, unique registration and triage of victims close to the impact site. Personal identification and further medical details can be added at any time in the process. Online application and connection of the various systems used by the different partners in disaster relief promote interoperability and enables patient tracking and tracing. ViTTS offers a real-time overview of victims to all involved disaster relief partners. This is necessary to generate an adequate disaster response with optimized resource allocation (care- and cost-effective) and prevents unnecessary public distress.

One of the deployments of the MIH was for the repatriated Dutch victims of the 2004 South Asian tsunami. Of the 500 Dutch that were in the affected area, 23 wounded victims were repatriated to the MIH on New Year's Eve 2004-2005. In line with the Dutch quarantine policy they had to be treated in quarantine. The MIH could receive all repatriated victims together for quarantine care.

The study described in **Chapter 5** evaluates the wound infections, culture results and resistance patterns seen in the group of wounded repatriated tsunami victims. Wound cultures showed a spectrum of pathogens that was different from the spectrum that is usually encountered in European hospitals. A combination of waterborne bacteria and a high prevalence of Gram-negative bacteria and enteric commensals was found in wound and surveillance cultures. Most wound infections were polymicrobial. Bacteria were often multi-drug resistant.

Disasters do not only have an impact on physical health, but on mental health as well. Yet, long-term studies that describe effect of disasters on both physical and psychological health combined are scarce. Most data come from cross-sectional, short-term studies on mental health alone. **Chapter 6** includes the group of wounded repatriated tsunami victims to the MIH in a prospective 5-year follow- up study on physical and psychological impact of the tsunami and quality of life (EUROQOL-5D+8). Tsunami exposure with concomitant injury had considerable middle and long-term physical and emotional impact. A third of the victims, after six months, rated their health worse than pre-disaster, and still a quarter after five years. Use of health care for trauma related complaints was 68% six months and 26 % five years post-disaster. One third still felt hindered in their daily activities by tsunami related physical and/or mental complaints after five years. Impact on daily activities and high health care use were not reflected in significantly lowered quality of life scores. No demographical, injury or psychological exposure characteristics could be related to quality of life outcomes. Three exceptions that were related to quality of health outcomes were: age, educational level, and ISS on the short term.

From the group of tsunami victims that was repatriated to the MIH came a call for a communication platform that triggered the development of a Web service, described in **Chapter 7**. A multilingual website with combined modalities for emotional care and research after a natural disaster proved feasible. Within three weeks after the tsunami, an open, online service was launched to foster (community) support in the aftermath of the disaster. It combined four functionalities that were previously only used separately:

1. an information portal
2. a forum aimed at community building
3. self-assessment tools and a research survey
4. e-Consultation with a professional

The website was available in 15 languages. Ninety-five percent of all visitors came from Europe or the United States. The portal had over 36.800 unique visitors in the first two years. The forum contained a lot of individual stories from victims as well as responses from people that offered to act as a sounding board or to give explicit help. It showed to be a source of mutual support and help. A large part of the Dutch tsunami victims could be reached through the site for the self-assessment and survey. The e-Consult modality was used by victims up until two years after the event. Over time, the web portal also served as a memorial archive for anniversary meetings and follow-up incentives.
Difficulties we experienced in the set-up and use of the web service were lack of funding, time pressure, victim-anonymisation, international collaboration, and long-term maintenance.
Of the estimated total of 500 Dutch tsunami victiims, 144 unique respondents (59 males and 85 females) participated in the survey on the site with 175 assessments at various time periods. **Chapter 8** describes the results of this open online survey. Health outcomes were: Symptom Checklist 90 (SCL-90[9, 10]), Impact of Event Scale[11], and Beck Depression Inventory II.[12] Correlations were calculated with socio-demographic as well as disaster-related factors: physical injury, medical care, loss of loved ones and duration of threat to life. Assessments were clustered in 4 post-disaster time periods (0-3, 4-6, 7-30 and 31-48 months). Across these periods, SCL-90 scores were significantly higher than the reference population10 ($p < 0.001$), with a significant linear downward trend over time ($p = 0.001$). Despite a clear trend to recovery over 4 years, 22% still reported high psychological and physical distress 4 years post-disaster. The same pattern occurred for the Impact of Event Scale ($p < 0.001$), and the Beck Depression Inventory ($p = 0.002$). Physical injury, medical care or loss of loved ones at the time of disaster, were not associated with higher total SCL-90 scores or somatic sub-scores. Both duration of threat to life and female sex were correlated with all measured outcome parameters.

General Discussion and Conclusions

Disaster medicine starts long before an actual disaster or major incident occurs. Planning, training, cooperation and a change in concepts and approaches are important to eventually mount an effective and adequate response.[1, 2, 13] Although disasters are unpredictable and sudden, they are not necessarily random and can be anticipated.[14]
The risks for major accidents and disasters have significantly increased parallel to the technical and political development of the world.[1, 14] A growing world population, urbanisation, increased production and transportation of hazardous material, infectious agents, global terrorism and environmental degradation are among the factors that increase hazards and vulnerabilities.[1, 4, 15]
As the most common and likely disasters that may confront us are those involving physical injury, the integral involvement of surgeons in planning and care is mandatory.[4, 13, 16]

The MIH is a unique facility that can contribute to preparedness for the medical management of the surge of casualties from a major incident or disaster.
Its contribution is not limited to providing directly available resources without impact on regular care. It also offers expertise, infrastructure, organisation, support systems, training, research and systematic working methods adapted to provide the greatest good for the greatest amount of people in case of multiple simultaneous victims. Pre-arranged cooperation, between the military (historically well-prepared and trained to cope with mass casualty events[4]), a trauma center and the National Poison and Information Center add to its value.
Group-wise treatment relief for incident victims showed to be advantageous for overview, logistics, registration, quarantine, emotional support and (pre)arrangements for family, media and security.
In the repatriation of victims (first and second scenario), the MIH has proven its added value in availability of the total range of care without quarantine restrictions. This facilitates rapid repatriation and initiation of treatment, which is often not possible in a war/mission setting. It also reduces the risk for regular care and has proven to reduce further quarantine efforts. The studies in Chapters 3 and 5 of this thesis reinforce the value and necessity of strict quarantine care and appropriate microbiological assessment of foreign or repatriated patients, to prevent transmission of multi-resistant organisms to other patients and health care personnel.

In the deployments for national major incidents (the third opening scenario) the MIH performed well. The overall deployment for this scenario however was

relatively low. Its availability and capacity were not used to maximum advantage. Some examples in which the MIH could have been used for relief but was not deployed, are the Enschede Fireworks Disaster (2000), the New Year's eve Café fire (2001)[17] and the Poldercrash (2009).[18]
Performance of the regular Dutch trauma centers and hospitals proved to be adequate for multiple trauma/incident patients in terms of direct in-hospital care within surge capacity.[18-20] Leap-frogging could guard these capacities provided that the incident is not too extensive. It also showed to complicate communication, patient overview, logistics, family support, media and security.[17, 18, 20] Furthermore it had a great impact on regular care. Several hospitals were over- or underalerted.[17, 18, 20] In mass casualty incidents, large numbers of casualties that are not critically injured threaten to delay the recognition and care of a small majority with urgent and salvable life-threatening injuries at immediate risk of death (T1 triage class).[3, 4] The literature reports that approximately 5-25% of the total casualty load in a mass casualty incident has critical injuries needing immediate treatment.[4, 21]
(Inter)national research indicates that trauma systems can have a favourable effect on the quality of care of victims of a (major) incident or disaster.[22-26] In these systems, distribution of casualties from the scene is orchestrated centrally. Critically injured patients are taken to a level 1 trauma center if possible.
In The Netherlands, the organisation of disaster relief in The Netherlands is still a 'work in progress'. Responsibilities are currently parcelled out over 25 safety regions for the Accident and Disaster Medical Response Organisation (GHOR), police and fire department. Around the 11 Dutch Trauma centers, 11 different regions are formed for hospital trauma care. Their aim is to coordinate and maintain a nationally covering network of traumacare, which should be further developed and form the backbone of disaster relief to parallel the above mentioned trauma systems.

The MIH could make a valuable contribution in effective use of overall available capacity and delivering the best care to the greatest number of patients. This does not necessarily mean that all victims should always go to the MIH. It should rather be regarded as a facility with directly available, extensive possibilities within a trauma system. A good distribution could be to transport T1 victims to level 1 trauma centers and group T2 and T3 victims to the MIH. This allows trauma centers and local hospitals to focus on T1 victims and unavoidable self-referrals. Meanwhile, the MIH can triage and sort out the bulk of victims, eventually with some of the T1 victims, in a situation that is designed for further triage through successive echelons of care, and where other conditions for good group-wise treatment are prearranged; reserved availability of resources (100-300 beds; 12 ICU,

38 medium care and 50 low care, OR, radiology etc.), registration, psychological support, media, family issues and security. This would facilitate pre-hospital organisation and quicker patient overview[18], which will eventually benefit delivery of the right care to the right patient within the right time.
Distance of a facility to the scene is a relative issue. Time to adequate treatment is indicated to be a more important factor for outcome.[4, 27] The MIH (Utrecht) is located centrally in The Netherlands. Direct availability and simplicity in pre-hospital routing will further benefit time to treatment. For example, in the Polder Crash (Schiphol Amsterdam) the MIH was well within 60 km of the accident, comparable to distances to some of the other deployed hospitals.[18] In this case the MIH was not used for the initial relief and it took a few hours, waiting in the field and several transfers for patients to arrive at a suitable facility.

A recent incident in a burning retirement home (June 2011) showed that the MIH was able to deliver quick adequate care for multiple victims, including T1 victims. An extensive fire necessitated evacuation of over 100 elderly residents. Some could be treated on the scene. All people that were in need of further treatment were admitted to the MIH. The entire major incident relief operation remained clear and effective. The MIH was operational 20 minutes after the request for deployment. Nineteen minutes later the first (T1) patient arrived. In total 49 evacuated elderly were admitted to the MIH. Nine needed ICU treatment for inhalation trauma and 6 medium care treatment.

National and international major incident reports show that information exchange, communication, and registration are recurrent major barriers to an effective response.[17, 27-30] This is something we should address to improve preparedness and outcome. Effective coordination and control of emergency response depends on the effective coordination and control of information-sharing.[31] An analysis of medical response problems during five disasters in The Netherlands between 1996 and 2005[32] and the report from the Polder Crash in 2009[18] emphasise the need to improve this information processing during a disaster, currently insufficient in The Netherlands.

A victim tracking and tracing system like ViTTS can help to prevent unnecessary additional suffering caused by lack of patient overview, which results in inefficient use of (medical) resources and uncertainty among relatives.
The essence of ViTTS is to promote interoperability between the different systems of all the partners in disaster relief and to start unique registration of victims close to the impact site.
As the pre-existsing infrastructure can not be relied upon in disaster situations,

information sharing in emergency response requires that this communication infrastructure be brought to the scene by the responders.[31] In the ViTTS, ambulances at the scene form the network, with redundancy and several fallback options. When the scale of the incident would require a more extensive response, the capacity will be more robust as more ambulances participate, compensating for more extensive use of the network. This is in line with the concept of peer to peer networks.[31]

A technical solution alone would not solve the bottleneck of information management during disasters.[3, 33] ViTTS does not replace existing systems. It enables interoperability between the different systems of the partners in the chain by connecting them. The developed standards promote uniform information provision, which is necessary for good interoperability of the systems through the data bus. Furthermore, developing of standards and predefining access to parts of the information in the data bus stimulated partners in the chain to define their information needs, and made them aware of the value of information sharing and cooperation between partners.

Online application and connection of the different systems used by the diverse organisations in disaster relief makes real-time overview of victim flow (quantity, seriousness of injury, location) available to all involved disaster relief partners.

Thereby, the ViTTS provides early management information to the chain of command; critical for an adequate disaster response with optimized resource allocation (care- and cost-effective). Ambulances and transport can be sized and coordinated according to need. Patients can be transferred to the hospital that has relevant capacity, benefitting the time to treatment. Hospitals can adjust their capacity planning and level of preparedness according to the real-time overview from the disaster site. Furthermore they can dispose of prehospital data of their arriving/expected patients, currently often missing.[20] Altogether, this will help to optimize the coordination of the response and the allocation of resources, eventually benefitting the outcome for the group as a whole. Furthermore, early availability of information on the amount of victims, the seriousness of their injuries and their location can help to avoid unnecessary public distress.

The ViTTS described in thesis offers a good functioning prototype. Implementation of the ViTTS however, is a national and governmental matter. With the current, further developed technical possibilities it will become even easier to construct a nationwide system based on this prototype. It is a versatile solution that can be adapted to future developments of other technologies.

There are few research-based studies on victim tracing and tracking in disasters[34, 35] and a limited number of reports from simulated pilot tests of other systems. Some systems describe intelligent triage tags that provide active location tracking[36-38] and/or embedded vital monitoring components.[39] As the ViTTS data bus is not dependent on one single system, it could also be coupled to, for example, RFID (Radio Frequency Identification). Currently, besides the advantages that RFID could have[40] (e.g. active localization and less operator dependency), it still holds too many drawbacks and obstacles for implementation. These concern reliability, privacy/security threats and continuingly high costs of tags, infrastructure and middle ware. Maintenance costs remain unclear and there is a lack of interoperability, standards and tested best practices.[41] At this stage, barcodes as used in the ViTTS, are to be preferred. They can be used on the already existing triage cards in The Netherlands. Barcode technology is already used daily in every Dutch hospital as well as in the public domain. Barcodes have ease of use, speed, proven accuracy[6, 7], low carrier and hardware cost[41], fall back option on manual readout, easy maintenance and distribution of stock. In this set-up, the barcode injury cards and the ViTTS combine simplicity[1, 42] with the advantage of electronically and online registered data, resulting in dynamic use.

Besides physical injury, disasters can have a profound impact on mental health. Long-term studies on effects on both physical and mental health as well as on quality of life are scarce. The long-term studies in this thesis demonstrate the high impact of physical and mental complaints on daily activities, use of health care as well as psychological and physical distress. Despite a trend to recovery, these effects were also seen at four to five years post disaster.
This demonstrates the need for a combined approach with physical as well as mental care for victims.
Surgery and psychiatry may be more closely related than one would assess at first sight, especially in the field of trauma and disaster medicine. Mental health is an important part of disaster care.[43] Integration of physical and mental care for victims is mandatory when aiming for optimal health outcome. The field of disaster medicine needs to embrace both domains of expertise.
Further, long-term, combined follow-up studies are needed to assess the differential impact of trauma on both bodily/somatic function and emotional/mental health, and specifically to understand the trajectories of illness and recovery.[44-46] Awareness and insight into the integrated physical and emotional impact of disasters provide opportunities for surveillance and early treatment.
As the Internet has become ubiquitous in Western society and online communities expand rapidly, opportunities arise to offer care and perform research with

the Internet as a platform. Web-based services in the aftermath of disasters, like the web service described in Chapter 7 of this thesis, support community building and deliver patient-centred, easily accessible information and care. Moreover, online support systems can contribute to empowerment of victims and to resilience. More than two thirds of adults look for health information online. Peer reference is often valued above expert advice. Health issues including mental health are no exception. The influence of social media and online communities is changing the way healthcare can and will be delivered; we live in an era where there is an apparent need for contact online. This is even more relevant around life-changing events such as experiencing a disaster. It is not a question of *if* "healthcare" will be delivered through the Internet in addition to "regular" care systems, but rather *how well* we (will) use the Internet and social media to meet the needs of disaster victims. Furthermore, the greater scale of aggregation of data about disaster victims that could be achieved online can contribute to better insights in trajectories of illness and recovery.
The sudden nature of a disaster puts time pressure on the development of online solutions and influenced the yield of our website. This highlights the necessity of developing methods and (inter) national collaborations in advance, securing funding, and learning from earlier initiatives.

In conclusion, disaster medicine starts long before an actual disaster or major incident deploys and does not stop until long after the event. Preparedness, cooperation and a paradigm change in concepts and approaches are mandatory to the eventual mounting of an effective and adequate response.
With the MIH, The Netherlands has a unique facility that contributes to preparedness for the medical management of the surge of casualties from major incidents or disasters. Better positioning of the MIH in the national and regional procedures in cooperation with the trauma centers is essential to and will further maximize its yield.
Information exchange problems and lack of patient overview need be addressed to improve preparedness and outcome. A Victim Tracing and Tracking system can provide patient overview and interoperability between the partners in disaster relief.
Besides physical injury, the psychological/emotional impact of exposure to a disaster can have a profound and long term impact on the health of victims. This requires a multidisciplinary approach of (after)care with long-term provisions. Web-services could be used more explicitly to support this goal. Growing Internet penetration worldwide and especially the rapid expansion of influence of online communities and social media offer new opportunities to deliver (self)care and perform research with the Internet as a platform.

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Chapter 10

Summary in Dutch
(samenvatting in het Nederlands)

List of abbreviations

Acknowledgements

List of publications

Curriculum vitae auctoris

Nederlandse samenvatting

Optimale zorg bieden aan een onverwacht groot aantal slachtoffers als bij een ramp of incident vereist voorbereiding en een andere benadering dan reguliere traumazorg. Per definitie overstijgt het aanbod de standaard zorgvoorzieningen van ziekenhuizen in kwalitatief en/of kwantitatief opzicht. De opvang van dergelijke patiënten interfereert met de zorg voor de reguliere patiënten in de ziekenhuizen. Daarnaast blijken het ontbreken van overzicht over de slachtoffers en de gebrekkige mogelijkheid tot informatie-uitwisseling tussen de partners in de rampenopvang terugkerende barrières voor het leveren van een optimale respons.

Hoofdstuk 2 beschrijft de ontwikkeling van een Calamiteiten Hospitaal als permanente, gereserveerde faciliteit om acuut gestructureerde opvang te bieden aan groepen slachtoffers van een ramp of incident. Het is een internationaal unieke voorziening, die tot stand gekomen is door samenwerking tussen een militair ziekenhuis, een groot academisch medisch centrum, een traumacentrum en het Nationale Vergiftiging & Informatiecentrum. Het is een 'slapend ziekenhuis', dat in slechts 15 minuten operationeel kan zijn om grote groepen slachtoffers op te vangen. Het beschikt over uitgebreide eigen faciliteiten: 300 bedden, een operatiecomplex, röntgenafdeling, intensive care capaciteit, een eigen luchtbehandelingsysteem, multidisciplinaire inzet en uitgebreide facilitaire ondersteuning.
Alles is gericht op het creëren van orde in een chaotische, onverwachte situatie en tegelijkertijd het optimaliseren van zorg en logistiek in elk mogelijk scenario. Triage van slachtoffers speelt hierin een hoofdrol.
Het Calamiteiten Hospitaal is inzetbaar bij de volgende vijf scenario's:

1. Oorlog(sdreiging), crisis of conflictmanagment waarbij grote aantallen militaire slachtoffers moeten worden opgevangen.
2. Incidenten in het buitenland waarbij groepen Nederlandse slachtoffers, burger of militair, repatriëring en medische zorg behoeven.
3. Specifieke calamiteiten, aanslagen of grote ongevallen in Nederland, die de reguliere opvangcapaciteit te boven gaan.
4. Internationale medische zorg voor behandeling van buitenlandse slachtoffers.
5. Quarantaine zorg voor patiënten met een bijzondere infectieziekte.

Als het ziekenhuis niet in gebuik is voor patiëntenopvang, is er expliciet ruimte voor training en wetenschappelijk onderzoek; iets wat in de dagelijkse kliniek vaak op de achtergrond raakt.

In **Hoofdstuk 3** wordt de geïmplementeerde organisatie en het gebruik van het Calamiteiten Hospitaal geëvalueerd. Dit is essentieel voor verdere verbetering van *preparedness*, het voorbereid zijn op een onverwachte ramp. Alle 34 openstellingen van de afgelopen 19 jaar, sinds de oprichting in 1991, worden geanalyseerd aan de hand van de punten uit een Europees gestandariseerd protocol voor rapportage van grote incidenten en rampen (Protocol for Reports from Major Accidents and Disasters). Het Calamiteiten Hospitaal blijkt voor de eerste 4 scenario's in staat adequate, groepsgewijze spoedzorg te bieden aan militairen en burgers, zowel bij nationale als internationale incidenten. Het vijfde scenario van quarantaine zorg voor een bijzondere infectieziekte heeft zich nog niet voorgedaan.

Groepsgewijze opvang heeft voordelen voor veel facetten van deze speciale zorg: het krijgen en behouden van overzicht, quarantaine, logistiek, registratie, communicatie, beveiliging, emotionele ondersteuning en opvang van familie en media.

Het feit dat het ziekenhuis wordt vrijgehouden voor dergelijke zorg garandeert beschikbaarheid (inclusief intensive care, röntgen- en operatiecapaciteit) en minimaliseert daarmee de impact op de reguliere zorg. Daarnaast maakt het de opvang van groepen patiënten die zorg in quarantaine behoeven mogelijk en overzichtelijk (bv. MRSA, SARS, chemische of biologische besmetting). Meerdere openstellingen van het Calamiteiten Hospitaal, alsook gevallen waarin het juist niet voor opvang werd gebruikt, illustreren het nut van opvang in isolatie. Wat betreft nationale incidenten is het Calamiteitenhospitaal niet altijd ingezet, terwijl het wel een substantiële bijdrage had kunnen leveren. Continue evaluaties, onderzoek en training resulteerden o.a. in de ontwikkeling van een patiëntenbarcodesysteem en diverse aanpassingen om preparedness te verbeteren. Aanbevelingen voor de toekomst naar aanleiding van de evaluatie zijn: verbetering van de positionering in regionale en nationale procedures; voortzetting van de toegewijde tijd en personeel voor training, onderzoek en ontwikkeling; verbetering van decontaminatiefaciliteiten; implementatie van gestandariseerde scoringssystemen en uitbreiding van registratiesystemen naar de prehospitale setting.

Goede zorg begint al lang vóór het ziekenhuis (prehospitaal). Om een oplossing te bieden voor de typische problemen in informatie(uitwisseling) bij incidenten en rampen en om registratie en overzicht van de slachtoffers voor alle partners in de rampenopvang mogelijk te maken, werd een online Slachtoffer Volgsysteem ontwikkeld. **Hoofdstuk 4** beschrijft de ontwikkeling en het testen hiervan. Het Slachtoffer Volgsysteem is gebaseerd op een draadloos netwerk, gegenereerd door routers op ambulances, met directe 'on-site' en online registratie van

slachtoffers het scannen van gewondenkaarten voorzien van een barcode. De online applicatie en de verbinding die het Slachtoffer Volgsysteem maakt met en tussen de verschillende systemen van alle partners in de rampenopvang bevordert interoperabiliteit en maakt 'tracing and tracking' van slachtoffers mogelijk. Gegenereerde informatie over een gewonde patiënt blijft bij de patiënt in de gehele keten van zorg.
Een 'realtime' overzicht van de slachtoffers, hun triagecode, locatie en bestemming komt daardoor voor alle partners in de rampenopvang binnen handbereik. Dit is nodig en van vitaal belang om een adequate 'disaster response' te genereren met optimale verdeling van middelen (zorg- en kosteneffectief). Daarnaast kan het onnodige publieke onrust door gebrek aan informatie voorkomen.

Op 26 december 2004 zorgde een zeebeving in de Indische Oceaan voor een enorme vloedgolf. Deze 'Asian tsunami' liet een spoor van vernieling achter. Het dodental wordt geschat op 230.000 mensen, afkomstig uit 14 landen. Er kwamen 36 Nederlanders om. Van de 500 Nederlanders die in het getroffen gebied waren werden 23 gewonde slachtoffers collectief gerepatrieerd naar het Calamiteitenhospitaal in de nieuwjaarsnacht van 2004-2005. De meesten van hen hadden een opname in Bangkok achter te rug en moesten - conform het Nederlandse MRSA protocol - in isolatie in een Nederlands ziekenhuis worden opgenomen.

In **Hoofdstuk 5** worden de resultaten van kweken, resistentiepatronen en wondinfecties bij die groep gewonde gerepatrieerde slachtoffers van de 2004 tsunami in Azië geanalyseerd. De kweken tonen een spectrum van pathogenen dat anders is dan doorgaans in Europese ziekenhuizen wordt aangetroffen: een combinatie van watergedragen bacteriën, darmflora en gram-negatieve bacteriën. De meeste wondinfecties waren polymicrobieel (bevatten verschillende soorten bacteriën) en veel bacteriën bleken ongevoelig voor meerdere antibiotica (multi-resistent). Dit benadrukt de waarde (en noodzaak) van quarantaine opvang en screening van gerepatrieerde patiënten om overdracht aan andere patiënten en zorgverleners te voorkomen.

Het meemaken van een ramp kan naast het oplopen van lichamelijk letsel een grote en langdurige invloed hebben op de mentale gezondheid. Gecombineerde lange termijn studies naar de effecten van blootstelling aan een (natuur)ramp als de tsunami op de integrale (lichamelijke en geestelijke) gezondheid en kwaliteit van leven zijn echter schaars.

In **Hoofdstuk 6** wordt de gerepatrieerde groep gewonde slachtoffers van de tsunami naar het Calamiteiten Hospitaal gedurende 5 jaar vervolgd. Deze prospectieve studie onderzoekt de integrale impact van een dergelijke ramp en het gecombineerde effect op de kwaliteit van leven. Het meemaken van de tsunami met bijkomende verwondingen had zowel fysiek als emotioneel aanzienlijke impact op middellange en lange termijn. Na 6 maanden maakt twee derde van de patiënten voor gerelateerde klachten nog gebruik van gezondheidszorg en na 5 jaar is dit nog een kwart. Eén derde van de patiënten voelt zich na 5 jaar nog steeds beperkt in het dagelijks functioneren door lichamelijke en/of psychische klachten gerelateerd aan de tsunami. De invloed op dagelijkse activiteiten en hoog gebruik van zorg wordt niet weerspiegeld in significant lagere kwaliteit-van-leven-scores vergeleken met die van de doorsnee Nederlandse bevolking. Sommige ramp-gerelateerde psychische klachten werden pas na jaren manifest. Het effect van het meemaken van een dergelijke ramp op de integrale gezondheid vraagt om een multidisciplinaire benadering (die begint bij opvang) en lange termijn mogelijkheden voor nazorg.

Vanuit de groep tsunami slachtoffers die gerepatrieerd werden naar het Calamiteiten Hospitaal kwam een spontane roep om een communicatie-platform. Velen waren elkaar kwijt geweest, hadden dierbaren verloren, waren gewond geraakt en hadden korter of langer in doodsangst gezeten. Bijna allemaal hadden ze veel doden gezien, en de afschuw van de ramp zat onder de huid. Velen waren in ontreddering verbroederd. Na terugkeer naar het veilige Nederland was de ramp voor hen niet voorbij. Dit triggerde de opzet van een webservice om mensen met elkaar contact brengen.

Hoofdstuk 7 beschrijft de ontwikkeling en het gebruik van deze service met gecombineerde modaliteiten voor lotgenotencontact, psychische (zelf)zorg en onderzoek. De webservice was binnen drie weken na de tsunami online en beschikbaar in 15 talen. De website combineerde voor het eerst de volgende 4 functionaliteiten:

1. een informatie portal
2. een forum gericht op lotgenotencontact en community building
3. een zelfhulptest /survey
4. e-Consult met een professional.

De eerste 3 functionaliteiten richtten zich op zelfzorg. Community building, steun van lotgenoten en informatie droegen bij aan survivor 'empowerment' (het vergroten van intrinsieke kracht van mensen tot zelfredzaamheid). Dit is een krachtig middel gebleken voor stressreductie en vergroten van 'resilience' (het vermogen van de mens om ook onder of na moeilijke omstandigheden goed te functioneren en te groeien). De vierde funtionaliteit, e-Consult, bood toegang tot passende professionele hulpverlening. Op langere termijn functioneerde de website tevens als een 'memorial archive' bij de verjaring van de ramp of andere gebeurtenissen.

Via de Nederlandse portal van de webservice namen 144 van de in totaal 500 Nederlandse tsunami-getroffenen deel aan de online self-assessment survey. **Hoofdstuk 8** beschrijft de resultaten van deze survey. Hierbij werd in 4 tijdsvakken over een periode van 4 jaar gekeken naar het niveau van algemene psychologische en fysieke distress (Symptom Checklist, SCL-90), naar de mate van herbeleving en vermijding als psychologische reactie op een schokkende gebeurtenis (Impact of Event Scale, IES) en naar de aanwezigheid van depressieve klachten (Beck Depression Inventory BDI-II). Daarnaast werd het differentiële effect van 3 situationele parameters onderzocht: lichamelijk letsel, het verlies van een dierbare en de duur van ervaren levensgevaar tijdens de ramp op deze functiedomeinen. Alle scores (distress, impact, en depressie) waren op alle meetmomenten significant hoger in vergelijking met een niet blootgestelde referentiepopulatie, waarbij er een significante trend naar herstel te zien was over de periode van 4 jaar. Na 4 jaar lag echter bij één op de 5 deelnemers de SCL-90 score nog meer dan 1 standaard-deviatie boven de referentie. Een derde van de groep meldde nog steeds significante herbelevingen en vermijdingsgedrag. Eén op de 7 deelnemers vertoonde matig tot ernstige depressieve klachten. Lichamelijk letsel of verlies van een naaste door de ramp was niet gecorreleerd met slechtere uitkomsten. Naast vrouwelijke sexe was de duur van de ervaren doodsangst tijdens de ramp een sterke voorspeller voor klachten op de onderzochte functiedomeinen.

Concluderend kan gesteld worden dat rampen een groot kwalitatief en kwantitatief effect hebben op de gezondheid van slachtoffers. Daarnaast vergt de opvang van grote groepen slachtoffers bij rampen of grootschalige incidenten een andere insteek dan de reguliere traumazorg. Voorbereiding, informatie-uitwisseling en multidisciplinaire samenwerking zijn essentieel. In de acute fase geldt dit bijvoorbeeld tussen de 'medische keten', politie, brandweer, defensie, overheid en organisaties als het Rode Kruis. Een (online) slachtoffer volgsysteem kan overzicht en interoperabiliteit verbeteren en daarmee bijdragen aan een betere opvang en uitkomst op individueel en groepsniveau. Met het centraal gelegen Calamiteiten Hospitaal heeft Nederland een unieke voorziening, die een wezenlijke bijdrage kan leveren in de directe opvang van grote groepen patiënten door directe beschikbaarheid van middelen en expertise zonder een compromitterend effect op de continuïteit van de reguliere zorg. Een goede inbedding in nationale en regionale procedures en samenwerking met andere zorgverleners en traumacentra is echter essentieel voor openstelling en optimale inzetbaarheid.

Naast lichamelijk letsel kan de psychologische/emotionele impact van blootstelling aan een ramp grote en langdurige gevolgen hebben voor de gezondheid van slachtoffers. Dit vraagt om een multidisciplinaire benadering van (na)zorg met aandacht voor lange termijn mogelijkheden. Hierbij kunnen webservices nadrukkelijker worden ingezet dan tot nu toe gebeurt. De explosieve groei van internet en online social communities bieden nieuwe instrumenten om gestructureerde (zelf)zorg te leveren en middels wetenschappelijk onderzoek kennis en behandelmogelijkheden te verbeteren.

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.NET	framework that allows interoperability between multiple programming languages
802.11	802.11 is a set of IEEE standards that govern wireless networking transmission methods.
AIS	Abbreviated Injury Scale
BDI-II	Beck Depression Inventory
C2000	Dutch national Tetra network especially for ambulance, fire department and police.
CER	Coordination, Evaluation and Report framework
CHERRIES	Checklist for Reporting Results of Internet E-Surveys
CMH	Central Military Hospital
DRI	Disaster-related Injury
EAN	European Article Numbering
EAN-128	European Article Numbering (also referred to as UCC 128, EAN 128, and USS Code 128); international barcode system
EQ-5D+	EuroQol-5D+ Instrument (5 dimensions of the EQ-5D complemented with a 6th dimension of cognition)
ER	Emergency Room
ERP	Emergency Response Protocol
GPRS	General Packet Radio Service (technique to send and receive information in the GSM network, sent in small pieces)
I-RIS	Internet Registration and Information System; web enabled application of the Red Cross for registration of victims and relatives
ICU	Intensive Care Unit
IES	Impact of Event Scale
IRB	Institutional Review Board
ISS	Injury Severity Score
ISTSS	International Society of Traumatic Stress Studies
MIH	Major Incident Hospital
MIMMS®	Major Incident Medical Management and Support
MRSA	Methicilline Resistant Staphylococcus Aureus
MTOS+	Major Trauma Outcome Study (data and triage)
NVIC	National Poison Information Centre
OR	Operation room
PBRS	Patient Barcode Registration System
PDA	Personal Digital Assistant (small portable device that combines computer- telephone-, fax and/or network functions)
PDEQ	Peritraumatic dissociative experiences questionnaire
PRMD	Protocol for Reports from Major accidents and Disasters
PTG	Post Traumatic Growth

PTSD	Post Traumatic Stress Disorder
RFID	Radio Frequency Identification
RTS	Revised Trauma Score
SARS	Severe Acute Respiratory Syndrome, caused by the SARS coronavirus
SCL-90	Symptom Checklist 90
SE	Standard Error
SRN	Service Relation Number
TETRA	Terrestrial Trunked Radio. Standard for mobile communication for public order and safety services
TGN	unique victim of disaster number
TISEI	acronym for Tsunami International Survey on Emotional Impact ('wisdom' in Japanese language)
TNO-ICT	Netherlands Organisation for Applied Scientific Research
UMCU	University Medical Centre Utrecht
UPC	Universal Product Code
VAS	Visual Analogue Scale
ViTTS	Victim Tracking and Tracing System
VPN	Vitual Private Network
WLAN	Wireless Local Area Network (LAN) often also gives access to the Internet, mostly based on 802.11-protocols.
XML	Extensible Markup Language (set of rules for encoding documents electronically)
ZIS	Hospital Information System

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Curriculum vitae auctoris

Geertruid Marie Heleen Marres was born on December 31th 1975 in Hilvarenbeek, the Netherlands. In 1994, she graduated from the Gymnasium at the Mill Hill College College in Goirle. After a few months of studying Health Sciences at the University of Nijmegen she could start in Maastricht with medical school, which she continued from 1995 at the University of Amsterdam. During medical school, the first experiences in scientific research were in Capetown, South Africa (Dr. Pieper, Prof. dr. HSA Heymans). In 2002 she returned to Africa for a clinical tropical medicine internship (Malawi, Prof. dr. PA Kager). She graduated cum laude from medical school in the same year.
After graduating she worked for one year and a half at the OLVG in Amsterdam (Dr. NJM Out). In July 2004 she started her general surgery residency program at the University Medical Centre Utrecht (UMCU, Prof. dr. IHM Borel Rinkes). During this academic part of her training she was involved in the care for repatriated wounded tsunami victims in the Major Incident Hospital. This was the inspiration for research and several projects that later resulted in this thesis. From 2006 on, she continued her residency program at the Amphia Hospital in Breda (Dr. L. van der Laan en Dr. J.H. Wijsman). During this period she conducted and finished her research for this thesis and completed the general surgery residency program.
Currently she works as a surgeon in the Jeroen Bosch Hospital in Den Bosch, where she will start a specialization program in lung surgery and abdominal oncology in January 2012 (Drs. RJ Bolhuis).
She is married to Joris Wels with whom she got a daughter in 2010.

Geertruid Marie Heleen Marres werd op 31 december 1975 geboren te Hilvarenbeek. In 1994 legde ze haar eindexamen Gymnasium af aan het Mill Hill College te Goirle. Na een paar maanden studie Gezondheidswetenschappen aan de Universiteit van Nijmegen werd ze alsnog nageplaatst voor Geneeskunde aan de Universiteit van Maastricht, waar ze haar propedeuse behaalde. In 1995 vervolgde zij haar studie Geneeskunde aan de Universiteit van Amsterdam. Tijdens haar studie deed ze haar eerste ervaring op met wetenschappelijk onderzoek in Kaapstad, Zuid Afrika (Dr. A. Pieper, Prof. dr. HSA Heymans). In 2002 keerde ze terug naar Afrika voor een tropencoschap in Malawi (Prof. dr. PA Kager). In het zelfde jaar behaalde zij cum laude haar artsexamen.
Hierna werkte ze anderhalf jaar als assistent geneeskunde niet in opleiding op de afdeling Heelkunde van het OLVG te Amsterdam (Dr. NJM Out). Op 1 juli 2004 begon zij haar opleiding tot algemeen chirurg in het UMC Utrecht (opleider Prof. dr. IHM Borel Rinkes). Hier was ze betrokken bij de opvang van tsunami slachtoffers in het calamiteitenhospitaal, wat inspireerde tot onderzoek, resulterend in dit proefschrift. Vanaf juli 2006 vervolgde zij haar heelkundige opleiding in het Amphia Ziekenhuis Breda, waar ze tijdens haar opleiding haar promotieonderzoek startte en afrondde. In mei 2011 voltooide ze hier haar opleiding tot chirurg (opleiders Dr. JH Wijsman en Dr. L van der Laan).
Thans werkt zij in het Jeroen Bosch Ziekenhuis waar ze vanaf 1 januari 2012 zal beginnen als chirurg in vervolgopleiding longchirurgie met nevenaandachtsgebied oncologische en gastrointestinale chirurgie (vervolgopleider Drs. RJ Bolhuis).
Ze is getrouwd met Joris Wels met wie zij in 2010 een dochter kreeg.