Brace for impact! A thesis on medical care following an airplane crash
Postma, Ingri

Citation for published version (APA):

General rights
It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations
If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: http://uba.uva.nl/en/contact, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.
Chapter 4

Patient distribution in a mass casualty event of an airplane crash

I.L.E. Postma, resident orthopaedic surgery, AMC Amsterdam
H. Weel, PhD student AMC Amsterdam
M.J. Heetveld, trauma surgeon Kennemer Gasthuis, Haarlem
I. vd Zande, former director safety region Kennemerland
T.S. Bijlsma, trauma surgeon, MCA Alkmaar
F.W. Bloemers, trauma surgeon, VuMC Amsterdam
J.C. Goslings, trauma surgeon, AMC Amsterdam

Based on:
Patient distribution in a mass casualty event of an airplane crash.
Injury. 2013 Nov;44(11):1574-8
Abstract

Introduction
Difficulties have been reported in the patient distribution during Mass Casualty Incidents. In this study the regional Patient Distribution Protocol (PDP) and the actual patient distribution after the 2009 Turkish Airlines crash near Amsterdam was analysed.

Methods
Analysis of the patient distribution of 126 surviving casualties of the crash was carried out by collecting data on medical treatment capacity, number of patients received per hospital, triage classification, Injury Severity Score (ISS), secondary transfers, distance from the crash site, and the critical mortality rate.

Results
The PDP contains ambiguous definitions of medical treatment capacity and was not followed. There were 14 receiving hospitals (distance from crash: 5.8–53.5 km); four hospitals received 133–213% of their medical treatment capacity, and 5 hospitals received 1 patient. Three hospitals within 20 km of the crash did not receive any casualties. Level I trauma centres received 89% of the 'critical' casualties and 92% of the casualties with ISS ≥16. Only 3 casualties were secondarily transferred, and no casualties died in, or on the way to hospital (critical mortality rate = 0%).

Conclusion
Patient distribution worked well after the crash as secondary transfers were low and the critical mortality rate was zero. However, the regional PDP was not followed in this MCI and casualties were unevenly distributed among hospitals. The PDP is unclear, and should be updated in co-operation between emergency services, surrounding hospitals, and Amsterdam Airport Schiphol as a high risk area.
Introduction

On February 25, 2009 flight TK1951 crashed near Amsterdam Airport Schiphol, the Netherlands. One hundred and thirty five occupants were aboard, 126 survived the crash. When dealing with a large amount of casualties with a high energy trauma mechanism, management of patient distribution is a challenge. Preparation for disasters and Mass Casualty Incidents (MCIs) is a difficult but important task. Numerous casualties must be triaged, transported and treated at the appropriate hospital without overwhelming any of the hospitals. Disaster protocols are developed to offer guidance in executing these tasks. Research literature highlights different kinds of problems in patient distribution during MCIs, but more importantly, the same errors seem to be repeated in subsequent disasters or MCIs. (1-6) To prepare for MCIs, it is important to evaluate and report the outcomes of previous MCIs. In this study, the patient distribution after the MCI of the Turkish Airlines crash on February 25 2009, near Amsterdam was evaluated. This paper describes the analysis of the following research questions:

1. How is medical response to Mass Casualty Incidents (MCIs) and patient distribution organised in the Netherlands, with special attention to high risk areas such as Amsterdam Airport Schiphol?
2. How was the patient distribution executed in this MCI and was it carried out according to the regional Patient Distribution Protocol (PDP)?

Figure 1: Time of arrival at Emergency Department
Chapter 4

Methods

We collected the national and regional MCI plans and protocols that were applicable to the airplane crash, in order to analyse the general MCI response plans and specifically the regional patient distribution protocol (PDP). (7-11) Since the crash some protocols have already been in revision. In this analysis the situation as it was at the time of the crash was studied.

For the second question we analysed the events on the day of the crash, by studying evaluation reports of the Dutch Safety Board and the evaluation report of the Public Order and Safety Inspectorate in co-operation with the Health Inspectorate. (12-14)

The medical charts of ambulances and hospitals of all casualties of the crash were analysed. We specifically looked at the number of casualties the hospitals received, whether these hospitals had activated their hospital disaster plan and the distance from the crash site to the receiving hospital. The latter was calculated with the route planner of the ANWB (Dutch Automobile Association). (15)

Additionally the triage classification (P1, P2, P3; box 1 chapter 2) of the casualties and their Injury Severity Score (ISS) were collected. (16-18) To evaluate the patient distribution outcome, the secondary transfers and critical mortality rate were studied. (1; 2) The critical mortality rate expresses the quality of triage and patient distribution as a ratio between critically injured casualties and in-hospital (or on transport) mortality. This is based on the fact that critically injured casualties benefit the most from rapid transport to an appropriate facility. We compared the data of the patient distribution after the crash to the regional PDP.

Results

The system

The Netherlands (16.7 million inhabitants, 41,526 square km) is divided into 25 Safety Regions. The safety regions have their own Emergency Services Centre (ESC), with 215 ambulance stations for almost 700 ambulances. (19) Each Safety Region is responsible for its regional disaster protocol, which should be in accordance with the national disaster protocols. Different high risk areas, involving different kinds of risks (e.g. North Sea Channel, chemical industry areas), all have their own protocols. Some high risk areas involve several safety regions. When an incident involves an airplane crash at Amsterdam Airport Schiphol the Aircraft Accident Schiphol
(AAS, Dutch acronym VOS) protocol is used. The medical response of this system is presented in Table 1. The ESC of each safety region, receives calls for emergency assistance and coordinates the dispatches of these emergency responders (police, fire department, and ambulance services).

In the Netherlands hospitals are equipped according to Level I, II or III standards. Level I hospitals have full trauma care facilities. When an MCI occurs, a number of hospitals can be put on alert by the ESC (Table 1) or can be requested to activate their hospital disaster plan (Dutch acronym: ZiROP). When the hospital disaster plan is activated, extra capacity is created to receive and treat casualties. The Netherlands also has a Major Incident Hospital situated at the Military Hospital in Utrecht, with a liaison with the University Medical Centre Utrecht. Within 30 min they are ready to receive 100 patients. If needed, this facility is able to upscale to 250–300 patients, within 1 hour (20).

### Table 1: Airplane Accident Schiphol (AAS)

<table>
<thead>
<tr>
<th>Scale</th>
<th>Type of incident</th>
<th>Medical Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAS 1</td>
<td>Pan-pan call</td>
<td>2 Ambulances; 1 Medical Officer</td>
</tr>
<tr>
<td>AAS 2-4</td>
<td>Mayday call</td>
<td>5-14 Ambulances; 1 Medical Combination Team*; 1-2 Medical officers; 1-6 Hospitals</td>
</tr>
<tr>
<td>AAS 5</td>
<td>Crash &lt;50 occupants</td>
<td>25 Ambulances; 1 Medical Combination Team*; 2 Medical Officers; 7-13 Hospitals</td>
</tr>
<tr>
<td>AAS 6</td>
<td>Crash 50-250 occupants</td>
<td>64 Ambulances; 5 Medical Combination Teams*; 4 Medical Officers; 7-13 Hospitals</td>
</tr>
<tr>
<td>AAS 7</td>
<td>Crash &gt;250 occupants</td>
<td>126 Ambulances; 10 Medical Combination Teams*; 7 Medical Officers; 13-22 Hospitals</td>
</tr>
</tbody>
</table>

*Medical Combination Team: 1 trauma team (doctor + nurse), 2 ambulance teams, 1 Rapid Response Team for Medical Assistance, (Dutch acronym, SIGMA team).

In case of an MCI, casualties are triaged at the scene following the critical/immediate (P1), serious/urgent (P2), and minor/delayed (P3) triage classification according to the Triage Sieve and Sort system used by the MIMMS (Major Incident Medical Management and Support). (16) Then the casualties are transported to hospital according to priority. The distribution of the casualties among different hospitals is executed according to the regional Patient Distribution Protocol (PDP) of the safety region involved.

Since 2008, Amsterdam Airport Schiphol has fallen under the responsibility of safety region Kennemerland. Geographically though, Schiphol lies on the border of 2 safety regions. The regional PDP was last updated in 2008. When the number of
casualties is high and exceeds the co-ordinating capacity of ambulance personnel and centralists, a special patient distribution coordinator is sent to the scene. (9; 11; 21)

In the existing PDP, the general medical treatment capacity (MTC) per hospital is defined as one critically or seriously injured patient (P1 or P2) per emergency team per hospital in the first hour. In the second hour an extra 2 P1 or P2 patients can be received per emergency team in Level I or II trauma centres. The PDP does not describe the number of emergency teams per hospital. (9)

The PDP mentions that, according to government requirements, in case of an MCI, hospitals should be able to clear 3% of their total bed capacity. However, the PDP also states that in daily practice hospitals only agree to clearing 1%, because 3% does not appear to be reasonably possible. We consider this 3% medical treatment capacity as the maximum number of casualties able to be presented at the emergency department. In the regional PDP of safety region Kennemerland, there is information about 30 hospitals with a (presumed) total bed capacity of 14,398 beds. These total bed capacity numbers, however, are actually outdated because of the mergers of several hospitals and the increase in outpatient treatments. In the PDP, medical treatment capacity numbers are mentioned based on 1% and 3% of total bed capacity. The receiving hospitals and their medical treatment capacity are in Table 2.

The distribution of casualties is further decided upon by the triage classification of the casualties and the proximity of the hospitals. The PDP has the rationale that, in MCIs in the primary distribution phase, no consideration is given to injury type or severity (e.g. burn injuries). Only in the secondary (definitive) distribution phase may patients be transferred to specialised centres if necessary.

The Events

After the Turkish Airlines crash, the first reports of the accident came into the Emergency Services Centre (ESC) one minute after the crash at 10:27 a.m. (12; 14)

Eighty two ambulances from different regions were dispatched, as were the medical officers (Dutch acronym OvDG) and 3 Helicopter Emergency Medical Service teams (HEMS, Dutch acronym MMT). Difficulties in communication and distribution of tasks led to some response units being informed late. The first ambulance was alerted in 2 minutes and the first to arrive at the crash did so after 18 minutes. The first helicopter emergency medical team was alerted 35 minutes after the crash and arrived 55 minutes after the crash.
The person that was on call as the patient distribution coordinator was, at the moment of the crash, also working as an operator at the ESC and could therefore not execute his task as patient distribution coordinator. An ambulance nurse at the scene was appointed, ad hoc, as a substitute coordinator, but was not acquainted with the regional PDP. It was later reported by officials that the actual patient distribution coordinator on call was also not familiar with the actual PDP. (14)

Approximately one hour after the crash, the estimation of the number of casualties was 16 P1, 30 P2 and about 80 P3. At 14:00 (3.5 h after the crash) the reports were 25 P1, approximately 25 P2, about 60 P3 and 9 fatalities. (12; 14) At first, about half of the casualties were transported directly to hospitals by ambulance or casualty bus. At a casualty clearing station, some of the previously triaged P3 casualties were found to have major injuries at re-triage.

At this point all remaining casualties were also transported to hospital. It was difficult to retrieve much precise information about triage. Most pre-hospital triage information was either not well documented or lost. In-hospital triage information was based on retrospective interviews with receiving hospitals and was published in the evaluation report of the Dutch Public Order and Safety
Inspectorate. (12) The ISS (Injury Severity Scores) (calculated from the medical records of all patients) are presented in Table 3. One of the 13 patients with an ISS $\geq 16$ was not immediately transported to a Level I trauma centre, but was first evaluated at a Level III hospital. When the extent and type of his injuries were known and the patient was stable, he was transferred to a Level I trauma centre. Another 2 patients were transferred from a Level II hospital to a Level I hospital because the receiving hospital lacked the specialised facilities to treat their injuries.

Results of the time until presentation at the emergency department in Figure 1. Nine people did not survive the crash; they all died at the scene. No casualties died in or on the way to hospital; the ‘critical mortality rate’ therefore was 0%. (1; 2; 22)

The ambulances transported the casualties to 14 different hospitals varying from 5.8 to 53.5 km from the crash site (Table 2). There were 4 hospitals (1 Level II, 3 Level III) within 25 kilometres of the crash that did not receive any casualties. Two casualties left the crash site by themselves, but came to a hospital later for a physical examination. These 2 casualties are not included in our results.

At first 3 regional hospitals (Level II and III) were alerted by the ESC 24 minutes after the crash. About 15 minutes later, two 2 Level I hospitals received a request to put their disaster plan into action, as did another 4 smaller hospitals (3 of which were alerted earlier). (14) One other hospital close to the crash site (11.6 km) put its disaster plan into action, without formal request from the ESC. The hospitals are presented in Table 2. The Major Incident Hospital in Utrecht was not requested to prepare to receive casualties.

Four hospitals with activated disaster plans received more patients (147–213%) than their 3% medical treatment capacity. Five hospitals, one of which was officially requested to activate the hospital disaster plan, only received 1 patient. It was orally reported to the authors that, because of a failing communication system and the lack of patient distribution co-ordination, ambulance personnel transported patients to hospitals at their own discretion. This was often to the hospital they were most acquainted with.
Table 3: No. of casualties per hospital

<table>
<thead>
<tr>
<th></th>
<th>Level I</th>
<th>Level II</th>
<th>Level III</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>31 (89%)</td>
<td>4 (11%)</td>
<td>-</td>
<td>35</td>
</tr>
<tr>
<td>P2</td>
<td>23 (57%)</td>
<td>7 (18%)</td>
<td>10 (25%)</td>
<td>40</td>
</tr>
<tr>
<td>P3</td>
<td>5 (10%)</td>
<td>37 (79%)</td>
<td>7 (14%)</td>
<td>49</td>
</tr>
<tr>
<td>ISS≥16</td>
<td>12 (92%) (+1*)</td>
<td>-</td>
<td>1 (8%)(-1*)</td>
<td>13</td>
</tr>
<tr>
<td>ISS 8-15</td>
<td>14 (64%) (+2*)</td>
<td>6 (27%)(-2*)</td>
<td>2 (9%)</td>
<td>22</td>
</tr>
<tr>
<td>ISS&lt;8</td>
<td>26 (29%)</td>
<td>45 (51%)</td>
<td>18 (20%)</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>52</td>
<td>51</td>
<td>21</td>
<td>124</td>
</tr>
</tbody>
</table>

Row 1-3: estimated numbers as reported in investigational reports (12; 14)
* +1, +2 and -1, -2: refers to secondary transfers

Discussion

This study found that without formally using a PDP, a critical mortality rate of 0% can be accomplished in an MCI with 126 casualties. It was not possible however to evaluate the effects on morbidity. However patient distribution would be faster and safer if a clear protocol was implemented by the emergency services.

The impact zone of the runways and approach routes of Schiphol Airport extend into 4 safety regions. Only 3 hospitals, out of 11 situated within 25 km of Schiphol Airport, are within the geographical borders of the safety region concerned with the management of an MCI at the airport. The 82 responding ambulances came from at least 5 different safety regions. This shows that in the Netherlands, patient distribution in an MCI, especially in high risk areas like an international airport, almost automatically involves several safety regions.

The existing PDP is based on a rationale of primary distribution without attention to specific injuries and specialisations available in hospitals. In this MCI the patients were casualties of an airplane crash that ended up in a field. It was difficult for the walking casualties to get away on their own, so emergency services had good control over patient distribution. If an MCI were to take place in an urban setting, casualties would be taken to hospitals in civilian cars or the ‘walking wounded’ would go on foot. This would result in an uncontrolled flow of casualties at the nearest hospital. (1; 23; 24) This must be taken into consideration when planning patient distribution.

The existing regional PDP does not clearly define how many casualties each hospital can receive and how many emergency teams are present. The 3% medical
treatment capacity is based on total bed capacity, but does not reflect the true treatment capacity of hospitals' emergency department. The medical treatment capacity of the 2 Level I trauma centres in Amsterdam, as reported in the Patient Distribution Plan, is 26 and 17. In practice their actual treatment capacity in a Mass Casualty Incident (MCI) is likely to be different, if treatment capacity were based on available resources, like the number of trauma teams, trauma room capacity, operating theatre, ICU capacity, etc. (3; 25)

The execution of the patient distribution after the Turkish Airlines crash was sub-optimal, partially because of problems in communication, as has been reported in many other MCIs. (4; 6; 24-28) It also appears to have been difficult to implement the patient distribution protocol (PDP) because the patient distribution co-ordinator on call was not able to take upon his function and it later appeared that the assigned co-ordinators were not properly familiarised with the PDP of the safety region. The patient distribution co-ordinator and other officers on call must therefore be free from all other tasks, to be able to take on this duty in case of an MCI. Everyone involved in the management of an MCI should be properly trained for the individual task and this training should be repeated in MCI drills every few years.

The Dutch government has stated that ambulances should be able to reach 95% of all inhabitants within 15 minutes. (29) Despite the short distance, the first ambulance to reach the crash site in the Turkish airline crash, did so in 18 minutes, 3 minutes later than required. (14) The government also states that the assistance of the helicopter emergency medical services is only useful when they can provide this assistance within 30 minutes. (30-29) In this crash the helicopter emergency medical services were called upon only after 35 minutes. The first helicopter to arrive after 55 min also did not meet the current national standards. Only 4 (11%) of the critically injured (P1) casualties and 1 multi-trauma casualty (ISS ≥16) were not initially transported to a Level I trauma centre (Table 3). Just 3 secondary transfers were needed which demonstrates good patient distribution, as does the critical mortality rate, which was 0%. Although the patient distribution had no influence on the critical mortality rate; we cannot say whether it had an influence on morbidity.

In the Turkish Airlines crash it was not clear which Emergency Services Centre alerted which hospital or Helicopter Emergency Medical Teams. (14) Six hospitals in 3 safety regions received the request to put their hospital disaster plan into action more than 40 minutes after the crash. This is late, considering it takes time to execute the disaster plan.
Casualties were transported to 14 hospitals, half of which were more than 30 km away from the site of the crash. Four hospitals situated within 25 km by road, did not receive any patients. If all hospitals within 25 km had been considered, 11 hospitals would have been sufficient to cope with all casualties. Two of these hospitals are Level I, four Level II and five Level III, and have a total medical treatment capacity of 162. In this Mass Casualty Incident (MCI) it was not necessary to involve the Major Incident Hospital in Utrecht, because there was enough treatment capacity in the area. Whether the use of a major incident hospital would have been more efficient and practical in terms of costs, patient distribution, casualty identification, etc. has never been studied, to our knowledge.

Four hospitals received more casualties than described in the patient distribution protocol (PDP), exceeding their assigned (3%) medical treatment capacity by 133–223%. Four other hospitals nearby did not receive casualties and 3 hospitals received just 4–11% of their treatment capacity. One hospital, that was officially requested to put its disaster plan into action, received only 1 casualty. Another hospital that put its disaster plan into action without request (but did so because of close proximity to the crash site) received just 6 patients. Activating the hospital disaster plan and receiving only a few casualties resulted in unnecessary financial losses in this MCI.

After the Turkish Airlines crash, the safety region Kennemerland started to revise its patient distribution protocol and has taken into account suggestions made by the MOTAC study group based on this study. Efforts are being made to create a new nationwide rationale in patient distribution.

Conclusions

In this Mass Casualty Incident (MCI) the existing Patient Distribution Plan (PDP) appeared to be unclear and did not account enough for multi-regional medical response for MCIs in the large high risk area of Amsterdam Airport Schiphol. However, the critical mortality rate of 0% and low secondary transfer rate shows that patient distribution worked well in this crash. Lack of communication and a non-functioning PDP led to hospitals being uninformed about the expected casualties and to unnecessary loss of regular treatment capacity in some. We recommend that PDPs are revised to national standards with specifications for high risk areas like Schiphol Airport. The Emergency Services Centre, the hospitals and Schiphol Airport should cooperate in revising these PDPs.
References