

# Distribution of Casualties in a Mass-Casualty Incident with Three Local Hospitals in the Periphery of a Densely Populated Area: Lessons Learned from the Medical Management of a Terrorist Attack

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#### Abbreviations:

ALS = advanced life support  
BLS = basic life support  
EMS = emergency medical services  
HFC = (Israel) Home Front Command  
ICU = intensive care unit  
ISS = Injury Severity Scale  
MCI = mass-casualty incident  
MDA = Magen David Adom (Israel EMS)

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#### Abstract

**Introduction:** A mass-casualty incident (MCI) can occur in the periphery of a densely populated area, away from a metropolitan area. In such circumstances, the medical management of the casualties is expected to be difficult because the nearest hospital and the emergency medical services (EMS), only can offer limited resources. When coping with these types of events (i.e., limited medical capability in the nearby medical facilities), a quick response time and rational triage can have a great impact on the outcome of the victims. The objective of this study was to identify the lessons learned from the medical response to a terrorist attack that occurred on 05 December 2005, in Netanya, a small Israeli city.

**Methods:** Data were collected during and after the event from formal debriefings and from patient files. The data were processed using descriptive statistics and compared to those from previous events. The event is described according to Disastrous Incidents Systematic Analysis Through Components, Interactions, Results (DISAST-CIR) methodology.

**Results:** Four victims and the terrorist died as a result of this suicide bombing. A total of 131 patients were evacuated (by EMS or self-evacuation) to three nearby hospitals. Due to the proximity of the event to the ambulance dispatch station, the EMS response was quick. The first evacuation took place only three minutes after the explosion. Non-urgent patients were diverted to two close-circle hospitals, allowing the nearest hospital to treat urgent patients and to receive the majority of self-evacuated patients. The nearest hospital continued to receive patients for >6 hours after the explosion, 57 of them (78%) were self-evacuated.

**Conclusion:** The distribution of casualties from the scene plays a vital role in the management of a MCI that occurs in the outskirts of a densely populated area. Non-urgent patients should be referred to a hospital close to the scene of the event, but not the closest hospital. The nearest hospital should be prepared to treat urgent casualties, as well as a large number of self-evacuated patients.

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#### Introduction

The success of medical management during a mass-casualty incident (MCI) is dependent on the rational utilization of resources that will ensure the timely provision of the best possible treatment for the largest number of casualties. The challenge is even greater when the MCI occurs in the periphery of a densely populated area, far from a Level-1 Trauma Center. In comparison with Level-1 Trauma Centers, small hospitals have fewer resources and lim-

ited abilities to cope with a large number of injured patients. These regions might have limited emergency medical services (EMS), which complicates prehospital treatment and evacuation.

During the last decade, Israel has experienced hundreds of terrorist attacks, many of which resulted in a MCI.<sup>1-8</sup> Some of these MCIs occurred in the outskirts of a densely populated area. The lessons learned from MCIs occurring in these less populated areas demonstrated the importance of the nearby small hospitals in the immediate medical management of urgent casualties.<sup>3,4,7,8,12</sup>

On 05 December 2005, a suicide bomber detonated an explosive device near a shopping mall in the city of Netanya, Israel. Prior to the explosion, policemen and mall security officers unsuccessfully attempted to stop the bomber and to clear the populated area. Due to the proximity of the city's EMS station to the scene, the medical response to the event was quick. A total of 131 casualties were evacuated to three nearby hospitals, and three victims were announced dead at the scene.

This study identifies the lessons learned from this event and focuses on the differences between the three hospitals. A theory regarding the dynamics of the admission of mild casualties during a MCI also was examined.<sup>2</sup>

## Methods

The event is described according to the Disastrous Incidents Systematic Analysis Through-Components, Interactions, Results (DISAST-CIR) methodology.<sup>7-9</sup>

### *Pre-Event Organization*

Magen David Adom (MDA), Israel's national EMS system, operates dispatch stations in many cities and towns in Israel, including the city of Netanya. It also runs on-call ambulances that are scattered in strategic places and staffed with medics and paramedics. In case of a MCI or other emergency, these ambulances are dispatched in addition to the regular shift units to shorten the on-scene arrival time and to allow for quick accumulation of medical forces at the scene.

The Medical Department of the Israeli Home Front Command (HFC) communicates with all relevant organizations through a Medical Operations Center, acquiring and transmitting real-time information and instructions to manage MCIs and other medical emergencies. These organizations include all of the Israeli general hospitals, national and district MDA headquarters, other military or HFC units, the fire brigade, police headquarters, search-and-rescue units, military medical units (including nuclear, biological, and chemical units), the Israeli Air Force, and the Hazardous Materials Information Center. The Operations Center also communicates directly with the Ministry of Health.

### *The Event*

Magen David Adom dispatched a total of 47 units and 119 medical personnel (some of whom were cancelled on their way or used to respond to non-MCI related calls).<sup>10</sup> The response was rapid, and the first victim was evacuated from the scene only three minutes after the explosion.

Three nearby hospitals and two Level-1 Trauma Centers received early notification of the MCI, both from the MDA and from the HFC Medical Department, and were instructed by the latter to activate their MCI protocols. The MDA Central Headquarters requested reinforcement from the Air Force Command for three medical evacuation helicopters for primary evacuation to hospitals or secondary distribution. Home Front Command officers were dispatched to the disaster zone, MDA Central Headquarters, and hospitals. Home Front Command officers, physicians, and nurses gathered information and transmitted it to the Operations Center, hospitals, MDA, and other relevant organizations. An army MCI medical unit also was dispatched.

### *Post-Event*

Post-MCI debriefings were conducted for all of the relevant organizations, including the HFC Medical Department and the MDA. Each debriefing was performed according to a standardized protocol—with each organization reporting its data and answering questions. Such debriefings were closed to the media, in order to allow free communication between organizations. The data presented in this paper were retrieved from the HFC and MDA.<sup>10,11</sup>

Hospital records were collected for all patients ( $n = 131$ ) who were evaluated at Laniado, Hillel-Yafe, and Meir Hospitals in the hours following the attack. Data were coded and processed using Microsoft Excel 2003 (Microsoft Inc., Redmond, WA) software. Due to the relatively small number of casualties, only descriptive statistics were used.

## Results

### *Medical Components*

The city of Netanya has a single Level-3 Trauma Center, within the city limits (Laniado Hospital), and two Level-2 trauma centers within <30 minutes driving radius (Hillel-Yafe and Meir Hospitals). Level-1 Trauma Centers are approximately a 40-minute drive from the Haifa and Tel-Aviv metropolitan areas.

The quick medical response to the event allowed the first victim to be evacuated only three minutes after the explosion. This quick response can be explained by the proximity of the EMS dispatch station to the event. Ambulances and medical personnel were dispatched after hearing the explosion at the station before any calls were received. In addition, a large group of off-duty medical workers was present at the station because of a union meeting being held at the time of the explosion.<sup>10</sup> This allowed for a quick accumulation of medical personnel at the scene and at the headquarters. The medical management timetable is in Table 1. The components of the medical response are in Table 2 and the interactions are illustrated in Figure 1.

### *Distribution of Casualties (Primary Triage)*

Three victims and the suicide bomber died at the scene. The distribution of EMS and self-evacuated patients to the three hospitals, as well as the hospital triage at admission is graphed in Table 3. A total of 131 patients presented to the three nearby hospitals. Emergency medical services units

| Actual Time | Time from Incident (minutes) | Description of Event   |
|-------------|------------------------------|--|
| 11:30       | 0:00                         | Suicide bombing near Hasharon Mall, Natanya                    |
| 11:31       | 0:01                         | First ALS and first BLS ambulances arrive at the scene         |
| 11:31       | 0:01                         | Hospitals notified   |
| 11:33       | 0:03                         | First Victim evacuated by ambulance                            |
| 11:38       | 0:08                         | First casualty arrives at the hospital (mildly injured)        |
| 11:42       | 0:12                         | First urgent victim evacuated from the blast site              |
| 11:56       | 0:26                         | Last urgent victim evacuated from the blast site               |
| 14:19       | 2:49                         | Last victim evacuated by ambulance from the scene              |
| 17:49       | 6:19                         | Last self-evacuated victim arrived to the emergency department |

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**Table 1**—Timetable of the medical response to the MCI (ALS = advanced life support, BLS = basic life support)

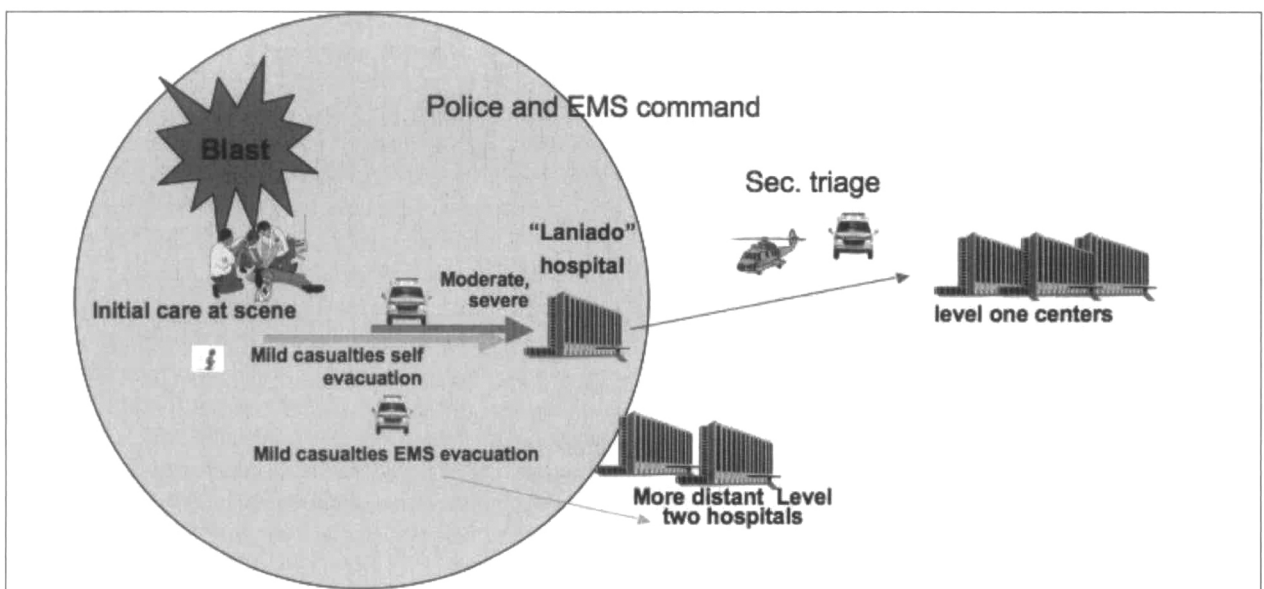
|                                |  |
|--------------------------------|--|
| Civilian Medical Teams         | EMS (Magen David Adom)<br>-33 ambulances<br>-12 mobile intensive care units<br>-2 mass-casualty vehicles<br><b>Total of 42 rescue and evacuation vehicles*</b> |
| Military Medical Teams         | -3 medical evacuation helicopters with air force medical teams<br>-1 military mass-casualty incident team from neighboring military clinic                     |
| Hospitals                      | -3 general hospitals (Level-2 and 3 Trauma Centers)<br>-2 remote Level-1 Trauma Centers (notified)**   |
| Medical command and operations | -Home Front Command Operational Center<br>-Emergency Medical Services District and National Operational Center<br>-Police Headquarters                         |

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**Table 2**—Units involved in MCI response

\* Some of the EMS units were canceled after dispatch, or been used for routine activities. Some of the ambulances returned to complete second round of evacuation

\*\* Casualties were not evacuated to remote Level-1 Trauma Centers



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**Figure 1**—Medical actions and interactions at the scene (EMS = emergency medical services)

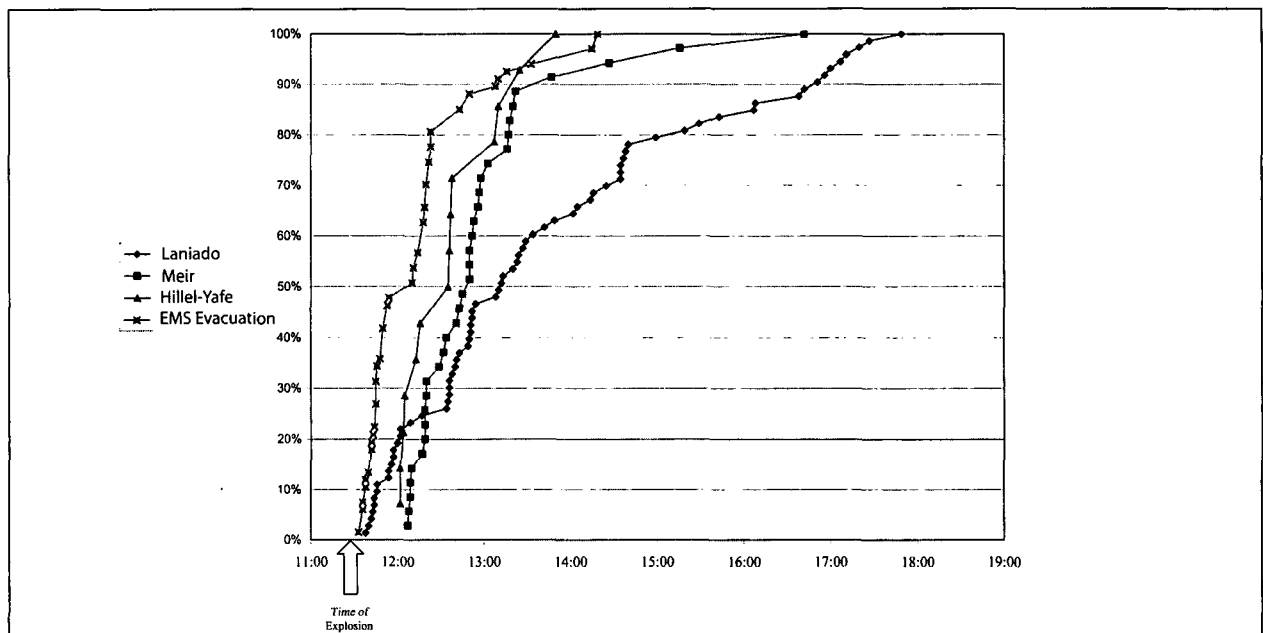
| Hospital     | Mild       | Moderate | Severe   | Total* n (%)    | Admissions | Surgeries |
|--------------|------------|----------|----------|-----------------|------------|-----------|
| Laniado      | 68         | 3        | 2**      | 73 (16)         | 10         | 4         |
| Hillel-Yafe  | 18         | 2        | 1        | 21 (21)         | 7          | 1         |
| Meir         | 37         | --       | --       | 37 (30)         | 1          | --        |
| <b>Total</b> | <b>123</b> | <b>5</b> | <b>3</b> | <b>131 (67)</b> | <b>18</b>  | <b>5</b>  |

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Table 3—Primary triage of casualties, admissions, and operations at the hospital

\*The number of patients evacuated by emergency medical services appear in parenthesis

\*\* One died in the emergency department a short time after arrival.



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Figure 2—The dynamics of evacuation and patients' presentation to the emergency department (EMS = emergency medical services)

evacuated a total of 67 (51%) casualties. Of the 67 patients evacuated by EMS, six were classified as urgent: four urgent patients were taken to the closest hospital (Laniado), and two were evacuated to the nearby Hillel-Yafe Hospital. Most of the self-evacuated patients arrived at the closest hospital, whereas the majority of patients treated in the other hospitals arrived by ambulances.

*Hospital Admissions*

The dynamics of the patient presentation rates are plotted in Figure 2. The presentation rates are *biphasic*, a short period characterized by a large number of presentations, followed by a longer period of low presentation rates to the emergency departments. However, it is evident that the rate of admission to Laniado Hospital (the immediate circle hospital) was lower than for the other hospitals and that the patients continued to arrive over a longer period of time. At the point in time of the last evacuation from the scene, only 70% of patients had arrived at Laniado

Hospital, 95% to Meir Hospital, and 100% of the patients arrived at Hillel-Yafe Hospital.

The Injury Severity Scale (ISS) scores of all patients was calculated retrospectively according to the data abstracted from medical files (Table 4). One of the victims died in the hospital. Only two of the patients had an injury severity scale score  $\geq 16$ . Of the patients who presented to the three hospitals, 95% had an ISS score  $< 9$ .

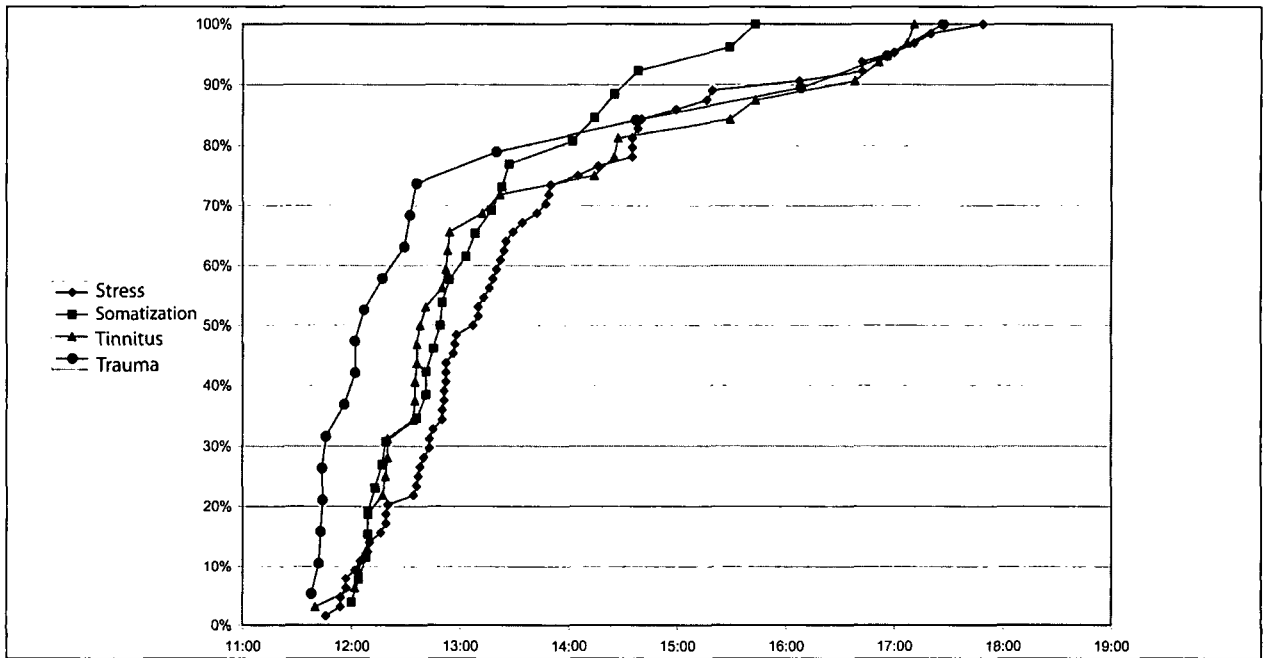
The distribution of the patients by chief complaint is plotted in Figure 3. Trauma patients were admitted to the emergency departments at a higher rate than were patients with other complaints (stress, tinnitus, or somatization); but the rate presentation of non-trauma patients could not be differentiated by complaint. The distribution of injuries among by body parts injured is in Table 5. All three hospitals received patients with similar distribution of injuries. Half of the presentations (65) were related to stress and/or anxiety and one-fourth were related to ear-nose-throat complaints including tinnitus.

Hospital resource utilization (imaging, surgical procedures, hospital admissions) is described in Table 6. Proportionately,

| Hospital    | ISS <9   | 9 ≤ ISS <16 | 16 ≤ ISS | Deceased | Total |
|-------------|----------|-------------|----------|----------|-------|
| Laniado     | 67       | 3           | 2        | 1        | 73    |
| Hillel-Yafe | 20       | 1           | --       | --       | 21    |
| Meir        | 37       | --          | --       | --       | 37    |
| Total (%)   | 124 (95) | 4 (3)       | 2 (1.5)  | 1 (<1)   | 131   |

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Table 4—Injury Severity Scale score (ISS)



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Figure 3—Dynamics of patients' admission by chief complaint

| Body part n (%)    | Laniado Hospital n (%) | Hillel-Yafe Hospital n (%) | Meir Hospital n (%) |
|--------------------|------------------------|----------------------------|---------------------|
| Head and neck      | 3 (4%)*                | 3 (14%)                    | --                  |
| Back and spine     | 4 (5%)                 | 1 (5%)                     | 1 (3%)              |
| Chest              | 2 (3%)                 | 2 (10%)                    | --                  |
| Abdomen            | --                     | 2 (10%)                    | --                  |
| Upper limb         | 3 (4%)                 | 2 (10%)                    | --                  |
| Lower limb         | 5 (7%)                 | 3 (14%)                    | 2 (5%)              |
| Stress and anxiety | 36 (49%)               | 10 (48%)                   | 19 (51%)            |
| Tinnitus + ENT     | 18 (25%)               | 5 (24%)                    | 12 (32%)            |
| Other complaints** | 16 (22%)               | 3 (14%)                    | 9 (24%)             |
| Known pregnancy    | 2 (3%)                 | 1 (5%)                     | 2 (5%)              |

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Table 5—Injuries by body parts (ENT = ear, nose, throat (otolaryngology))

\* Numbers in parentheses indicates percent of total number of admissions (per hospital)

\*\* "Other complaints" includes all non-traumatic complaints (e.g. headaches, weakness, dizziness, etc.)



| Hospital    | Imaging* n (%) | Operations n (%) | Hospitalizations n (%) |
|-------------|----------------|------------------|------------------------|
| Laniado     | 10 (14)        | 4 (5)            | 10 (14)                |
| Hillel-Yafe | 8 (38)         | 1 (5)            | 7 (33)                 |
| Meir        | 1 (3)          | --               | 1 (3)                  |

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**Table 6—Utilization of hospital resources**

\* Numbers in parentheses indicates percent of total number of admissions

| Time after blast (minutes) | Regular city shift units | Units from neighboring areas | Volunteers and other areas | Total     |
|----------------------------|--------------------------|------------------------------|----------------------------|-----------|
| <8                         | 1 BLS<br>1 ALS           | --                           | 6 BLS<br>1 ALS<br>1 MSV    | 10 units  |
| 8–15                       | 1 ALS                    | 2 BLS<br>1 ALS               | 6 BLS                      | 10 units  |
| 15–20                      | --                       | --                           | 2 BLS<br>2 ALS             | 4 units   |
| Total                      | 1 BLS<br>2 ALS           | 2 BLS<br>1 ALS               | 14 BLS<br>3 ALS<br>1 MSV   | 24 units* |

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**Table 7—Accumulation of medical resources\*\* at the scene, first 20 minutes (ALS = advanced life support, BLS = basic life support, MSV = Medical Supply Vehicle)**

\* Other units were canceled after dispatch, or been used for routine activities. Some of the ambulances returned to complete second round of evacuation.

\*\* BLS unit, ALS unit, MSV

one hospital (Hillel-Yafe) had a higher percentage of resource use despite relatively low ISS values. One-third of its patients required imaging and/or admission to the hospital.

*EMS Personnel and Vehicles*

The time of day and special circumstances of the event allowed for a quick accumulation of medical personnel on-scene despite the small size of the city. The time of the arrival of MDA responders at the scene is presented in Table 7. A total of 47 units (including 12 Advanced Life Support (ALS) units and two medical supply vehicles) were dispatched as part of MCI protocol of the MDA. Some of the units were canceled after dispatch. A total of 119 medical personnel participated in the medical efforts (including three physicians and 19 paramedics).

**Discussion**

The Hasharon Mall was the target of terrorist attacks in the past, the last attack occurred only five months prior to this event.<sup>7</sup>

The medical management of this recent terrorist attack in Netanya displayed a successful combination of prehospital and hospital coordination. This experience demonstrates the important role of Level-2 and Level-3 Trauma Centers in the management of a MCI when there is no nearby Level-1 Trauma Center. Communication between the various medical organizations and the implementation of lessons learned from previous events resulted in quick and synchronized response and rational triage.

*Medical Components*

The special circumstances in this event allowed for a quick response and fast accumulation of medical forces at the scene; however, a quick response can be attributed to the lessons learned from previous experiences.<sup>7,8</sup> Generally, the accumulation of medical forces is a greater challenge in the peripheries of densely populated areas. In Israel, emergency medical services consist of a large network of volunteers and on-call units. These factors facilitate the ability of the EMS to accumulate large forces in a short period of time. In a previous MCI at the Hasharon Mall, all patients requiring urgent treatment were evacuated within 11 minutes, and all non-urgent patients were evacuated from the scene within 20 minutes.<sup>7</sup>

*Distribution of Casualties (Primary Triage)*

In previous events, a large number of mildly injured patients were self-evacuated to the nearest hospital. This resulted in an overwhelming patient load to the small hospital's emergency department. It was recommended that the majority of non-urgent patients be diverted to other nearby hospitals, allowing the nearest hospital to treat urgent patients.<sup>7,8</sup> In the December event, only 16 patients were evacuated (by the MDA) to the nearest hospital, whereas 51 patients were evacuated to other local hospitals. Out of 64 patients that were self-evacuated, 57 (89%) arrived at the nearest hospital. The primary distribution of patients between the three hospitals allowed for better care of the urgent patients and eliminated the need for sec-

ondary distribution. The data in this study demonstrate a balanced triage that allowed optimal utilization of resources, and divided the burden almost evenly between the three hospitals.

It should be emphasized that this incident resulted in relatively mild injuries, as illustrated by the low number of surgical operations needed. Moreover, the "reserve capacity" of hospitals with regard to surgical theatres, intensive care unit (ICU) beds, and ventilators usually is sufficient to give immediate life-saving care to urgent casualties. In this scenario, which is typical of a suicide bomber event, the distribution of the severe casualties to the nearest hospital was appropriate. However, during an event with a higher load of severe trauma patients requiring surgery and/or intensive care and/or ventilatory support, it might be better to distribute the severely injured casualties among distant hospitals. The MDA and HFC keep a "hotline" with the hospitals during a MCI, which enables the communication of the correct status of available resources in the hospital. In the case of over-utilization of critical facilities, the destination of the primary distribution of casualties can be changed. In this incident, there was no problem with hospital resource availability, and therefore, the primary distribution of patients was appropriate for these circumstances.

#### Hospital Admissions

The distribution of the arrival of patients to the ED after a terrorist attack in the city of Beer-Sheva has been described in earlier works.<sup>2</sup> Two phases of patient arrival were identified by analyzing the data from the incident. The first phase was characterized by a high rate of admission with a majority of the patients presenting with typical stress-related complaints, while the second phase had a low rate of admission with more somatization complaints.

After the Netanya bombing, the biphasic behavior of patients admission was identified again. At Laniado Hospital (the nearest hospital), the duration of the first phase was longer, lasting approximately three hours, in

comparison with the other hospitals (approximately two hours). This time difference can be explained by the fact that the majority of patients in Laniado Hospital arrived by self-evacuation (57 of 73), whereas most of the patients in Hillel-Yafe and Meir Hospital were brought in by ambulances. Generally, self-evacuated patients arrive at a slower pace. In this incident, about 30% of the patients arrived at the Laniado Hospital's emergency department after the completion of EMS evacuations.

Although trauma patients appear to arrive earlier, a difference between "classical" stress reaction patients and those with somatization does not appear to be present. A possible explanation for the discrepancy between the findings of this incident to the findings in the Beer-Sheva event is that Netanya is more susceptible to terrorism than is Beer-Sheva.<sup>2</sup> The evacuation in the Netanya bombing was quick; therefore, fewer bystanders were exposed to the scene. In the Beer-Sheva event, only two people were injured directly from the explosion.

The understanding of the dynamics of patient arrival to the emergency department is important in the planning and management of mild-casualty treatment sites, and therefore, should be investigated further.

#### Conclusions

Level-2 and Level-3 Trauma Centers can play a crucial role in the medical management of a MCI in the periphery of densely populated areas. Every hospital should be prepared to manage a MCI, treat urgent patients, and receive a large number of non-urgent patients. If there is more than one hospital in the close circle [nearby region], non-urgent patients should not be evacuated to the nearest hospital, so that this hospital can be reserved to allow better treatment for the urgent patients, and care of self-evacuated patients. The nearest hospital should be prepared to receive a surge of new patients for a few hours after the event. Other hospitals in similar event circumstances can be expected to return to normal patient flow 2–3 hours following the event.

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