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Rehabilitation resource planning for mass casualty incidents: A retrospective analysis of blast and ballistic injuries

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ABSTRACT

Introduction: Mass casualty incidents (MCIs) involving extensive ballistic and explosive injuries place considerable pressure on healthcare resources. This study aimed to evaluate the rehabilitation resources required for individuals who sustained blast and ballistic injuries during an MCI.

Methods: A retrospective review was conducted using Electronic Medical Records (EMRs) of patients admitted to Sheba Medical Center (SMC), Israel, following an MCI on 7 October 2023. Patients diagnosed with gunshot wounds (GSW), or blast injuries (BI) were included. Data were collected over an almost 7-month period, focusing on injury patterns, rehabilitation department admissions, total hospital length of stay, and associated budgetary requirements.

Results: A total of 419 patients received rehabilitation at SMC: 205 with BI, 175 with GSW, 10 with both, and 9 with unknown injury causes. Two patients were under 18; the majority (76 %) of adults were aged 18–29. Military personnel comprised 90 % of the cohort, with 95 % male. Paediatric rehabilitation admitted the two minors, while adult patients were distributed across respiratory ($n = 7$), neurological ($n = 32$), head trauma ($n = 44$), and orthopaedic ($n = 68$) rehabilitation units. Additionally, 266 patients were treated in three newly established rehabilitation wards. BI patients experienced more complex, multi-trauma injuries, including traumatic brain injuries (11 %) and spinal cord injuries (11 %), underwent more surgical procedures, and had longer hospital stays. Consequently, the average rehabilitation cost per BI patient exceeded that of GSW patients.

Conclusion: Through strategic planning and multidisciplinary collaboration, SMC effectively managed a high volume of MCI-related injuries. BIs required significantly more rehabilitation resources than GSWs. These findings underscore the importance of preparedness, resource allocation, and interdepartmental coordination in managing rehabilitation during MCIs. SMC's experience offers valuable insights for global healthcare systems facing similar high-demand emergency scenarios.

Introduction

The incidence of mass casualty incidents (MCIs) is escalating globally, with higher numbers of individuals wounded by explosive or ballistic weapons[1,2],. Countries worldwide are now managing MCI emergencies with complex patterns of injuries with research emerging into the constraints and challenges faced by health systems[3]. The element of surprise combined with scant details on the number and types of injuries is a challenge, however, the management of MCI emergencies requires immediate recruitment of available hospital staff and resources[4]. Drawing information from past major MCIs provides an opportunity for health system planning, medical advancement and quality control[5].

Medical facilities have had to develop proactive strategies to manage MCIs[6]. Managing a high volume of patients with complex injury patterns frequently leaves hospital staff feeling unprepared[7]. Montan and colleagues demonstrated that a well-established simulation system could help identify and quantitatively assess the critical

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capacity-limiting factors during various phases of hospital MCI responses[8]. These simulation outcomes can serve as a basis for planning, training, implementing quality control, and making necessary improvements to enhance hospital medical surge capacity. The resource demands for managing blast injuries (BI) and gunshot wounds (GSW), highlighting the need for surgical procedures and theatre time, have been quantified[9]; however, the resource requirements for rehabilitating such injuries have not been explored.

This retrospective audit will detail how Sheba Medical Center (SMC), Israel, managed the significant influx of injured patients admitted for rehabilitation over a relatively short period following the major MCI in October 2023.

Context

Trauma is a leading cause of death among MCI victims under 44 years of age[10], with many fatalities occurring before reaching a medical facility[11]. Following MCIs, Israeli military personnel can provide primary care and immediate life saving measures (first responders), as well as prompt casualty transportation to hospitals. Subsequently, victims receive follow-up care and treatment from second and third responders (Fig. 1).

Aeromedical evacuations are provided by helicopter emergency medical services for civilian and military emergencies[12]. In Israel, first responders, including helicopter search and rescue teams, provide immediate life-saving measures and stabilisation. Second responders in medical facilities across Israel improve diagnostic and surgical capabilities through resuscitation rooms and emergency theatres for immediate and postoperative care. Finally, SMC, a third-tier responder centre, offers specialised care as patients move from emergency treatment to rehabilitation. This coordinated approach is vital for effectively managing and treating injured civilians and military personnel[13]. The civilian healthcare system in Israel has benefitted from the expertise of military medical teams, but safety and costs must be considered[14].

SMC, a tertiary hospital, is Israel's Central National Trauma Centre. It is located 64 km from the area of the 2023 MCI with an average aeromedical flight time by helicopter of 14 min[15]. SMC, the largest hospital in the Middle East is ranked by Newsweek as eighth in World's Best Hospitals 2025 (2025) and holds accreditation from the Joint Commission International. SMC hosts 159 medical departments and outpatient clinics, catering to over two million patients yearly (Fig. 2).

SMC has formulated standardised guidelines for significant incident planning and regularly rehearses exercises for future major incidents. Israeli-Medical personnel are experienced in setting up field hospitals [16]. In 2023, SMC swiftly established a new rehabilitation department in response to the large-scale MCI, which had involved the wide use of explosives and ballistic weapons. This rapid transformation demanded

Fig. 2. Sheba Medical Center (SMC) - this map (Wikimapia) shows SMC's extensive footprint, layout, and scope. Rehabilitation facilities including geriatric and psychiatric occupy a considerable portion of the centre.

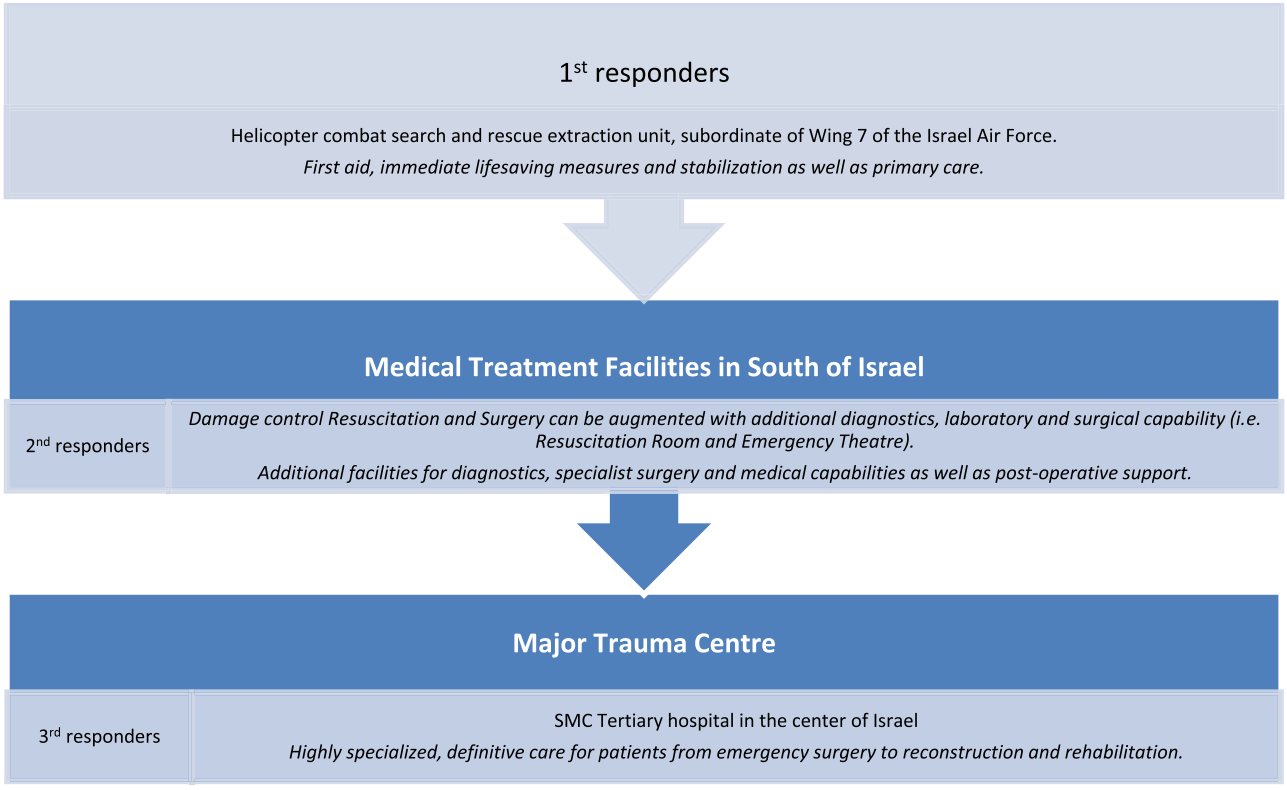


Fig. 1. Medical Support Structure in Israel showing the multi-tiered response plan for mass casualty incidents.

flexibility from all healthcare workers and the healthcare system. SMC orthopaedic surgeons, who performed emergency surgery including limb amputations, were the same physicians who continued through follow up and patient treatment management in the rehabilitation wards.

SMC utilises an electronic medical record (EMR) system known as Chameleon . A patient's medical history, medical images, diagnostic reports, treatment received, and a substantial amount of medical data are uploaded regularly into the system by the treating staff. EMRs, like Chameleon, have transformed healthcare delivery, patient care and outcomes as well as reducing costs[17]. Key findings of the benefits of using EMRs include improved healthcare information management, accessibility, and accuracy[18]. However, persistent challenges remain in the implementation and use of EMRs with some healthcare professionals showing caution in adopting their use[19]. Nonetheless, EMRs have been shown to assist medical professionals in maintaining accurate records at point of care, in real-time, enabling treatment information to be shared among medical and paramedical staff and other healthcare institutions[20] And enhancing continuity of care. The EMR is a comprehensive source of information that facilitates analysis of rehabilitation needs and costs as well as enabling retrospective research.

Aims of the study

The aims of this study were fourfold: 1) to collate demographic, injury and treatment data from EMRs regarding the sudden influx of MCI victims; 2) to demonstrate the decision-making processes involved in managing a sudden influx of patients from an MCI, represented by the increases in hospital beds and equipment; 3) to identify necessary adaptations for hospital wards and staffing; and 4) to determine the resources required to ensure best-practice standards for rehabilitation for injured civilians and military personnel following an MCI[21].

Methods

This retrospective audit used demographic information (i.e. patient identity number, date of birth, sex, military or civilian status), diagnoses and surgical procedures, analyses of injury patterns, of patients admitted to SMC during a period of almost seven months, from 7 October 2023 until 30 April 2024.

Data of patients with gunshot wounds (GSW) and blast injuries (BI) and receiving inpatient rehabilitation care were collected from the Chameleon EMR[22]. Patient length of stay (LOS) was also extracted and used as a proxy for the cost of inpatient rehabilitation[23]. The total number of hospitalisation days in the rehabilitation wards was calculated to gauge the variations in hospital bed requirements over the three-year period from 2022 to 2024.

Patients were identified using the ICD-9 codes[24] including E922.9 Gunshot Wound, V62.89 Victim of terrorism assault by shotgun, E923.9 Injury due to explosion [trauma], and synonyms E991.2 Injury due to war operations from other bullets, and E993.8 Injury due to explosive blast from weapons.

Permission to collect de-identified data was granted by the SMC Ethics Committee in collaboration with James Cook University, Australia (approval 8808–21-SMC). Key clinical and administrative data were exported from Chameleon to a Microsoft Excel 2016 spreadsheet for statistical analysis. Other data collected included rehabilitation department additional beds and staffing requirements and resource needs such as innovative technology (IT). Estimated financial investments for expansion and upgrade of the rehabilitation wards and purchasing IT were calculated as a percentage increase of the normal annual expenditure. Calculations were conducted using Stata 16 MP statistical software. Descriptive statistics included frequencies and percentages and inferential analysis was conducted using Fisher's Exact Test for nominal data. Statistical significance was set at $\alpha = 0.05$.

Results

Numbers of casualties

A total of 419 MCI survivors with GSWs and/or BIs were admitted to SMC for rehabilitation over the study period (Table 1). Military patients significantly dominated the 18-to-21-year age group when compared to civilian patients (42 % vs 7 %; $P < 0.001$), and both military (97 %) and civilian patients (70 %) were mainly male [25]. Overall, the patients included in the study were predominantly young adults between the ages of 18 and 29 years (76 %), with two minors under the age of 18 years. The types of injuries were similar between the sexes, although, as previously stated, more males ($n = 396$) were injured than females ($n = 25$). The primary injuries from GSW and BI in this cohort included penetrating trauma and complex bone fractures with vascular and nerve damage; shrapnel accounted for the highest number of injuries 215/419 (51.3 %). Following initial evaluation at the SMC emergency room and critical life-saving surgical and non-surgical procedures, injured military personnel and civilians were transferred to the main hospitalisation tower. Among these patients, 205 (49 %) suffered from BIs, 175 (42 %) had GSWs, 20 (5 %) were classified as "Other," and 10 (2 %) had both BIs and GSWs, while in nine (2 %) cases, the cause of injury was recorded as unknown (Table 2). Overall, military personnel experienced significantly more BIs than civilians (52 % vs 20 %; $P < 0.001$), while civilians endured significantly more GSWs compared to military personnel (61 % vs 40 %; $P = 0.012$).

The distribution of wounded patients across the rehabilitation wards at SMC during the study period is shown in Fig. 3. Four hundred and nineteen patients were included (378 military, 41 civilians). The highest number of injured patients (249 military, 17 civilian) were hosted in three new rehabilitation wards (A, B and C), followed by the orthopaedic ward (57 military, 11 civilian). Other wards (paediatric, neurologic, respiratory, and head trauma) hosted lower numbers of MCI injured patients. There was a notable disparity between military and civilian representations across all wards. The two paediatric patients were transferred to a specialised rehabilitation department in the SMC Children's Hospital building

Availability of beds

Within 3 days of the MCI, 14 rehabilitation beds had been added: four in respiratory rehabilitation, six in orthopaedic rehabilitation, another four in neurological rehabilitation, without any increase in staffing. One week later, an additional 18 beds became available in one of the geriatric rehabilitation wards, which was then transformed into the first wing of the novel rehabilitation department. Within 15 days, a second wing with 18 beds was opened. Within two and a half months three new rehabilitation wards (A, B and C), representing a total of 108

Table 1
Total number of war injuries admitted to Sheba Medical Center from 7 October 2023 until 30 April 2024: stratified by patient age, status and sex.

Patient age (years)	Patient Status (Civilian/Military)		
Frequency	Civilian	Military	p-value
<18	2 (5 %)	0 (0 %)	**0.009**
18–21	3 (7 %)	160 (42 %)	**<0.001**
22–29	13 (31 %)	141 (37 %)	**0.609**
30–44	11 (29 %)	66 (17 %)	**0.142**
44+	12 (29 %)	11 (3 %)	**<0.001**
Total	41 (100 %)	378 (100 %)	
Patient Sex	Civilian	Military	p-value
Male	29 (70 %)	367 (97 %)	**<0.001**
Female	12 (30 %)	11 (3 %)	
Total	41 (100 %)	378 (100 %)	

Key: p-two-sided p-value by Fisher's Exact Test.

Table 2
Mechanism of war injuries in civilians and military personnel patients treated at Sheba Medical Center from 7 October 2023 until 30 April 2024.

Mechanism of Injury	Patient Status		
Frequency	Civilian	Military	p-value
BI	8 (20 %)	197 (52 %)	**<0.001**
GSW	25 (61 %)	150 (40 %)	**0.012**
Other	5 (12 %)	15 (4 %)	**0.036**
BI + GSW	1 (2 %)	9 (2 %)	**>0.999**
Unknown	2 (5 %)	7 (2 %)	**0.217**
Total	41 (100 %)	378 (100 %)	

Key: BI – Ballistic Injuries; GSW – Gunshot Wounds; p-two-sided p-value by Fisher's Exact Test.

beds were opened within the geriatric rehabilitation building (Table 3), located approximately 500 m from the main adult rehabilitation building (Fig. 2). These additional wards increased the number of rehabilitation beds by 122 (Table 3 and Fig. 3). The hospital's strategy was to minimise patients' LOS in acute hospital wards, facilitating rapid transfers to rehabilitation departments, often within days, depending on the patient's medical status. Health staff education and training were implemented to promote further multidisciplinary collaboration amongst healthcare workers.

Costs to the health system

In the unique circumstances of the October 2023 MCI, injured civilians and military personnel were transferred to hospitals by military helicopters. Aeromedical evacuations, carried out by helicopter emergency medical services, are expensive, with the exact cost depending on the distance from the injury site or battlefield to a peripheral hospital or directly to SMC. The cost also varies based on the helicopter type, the time of service (day/night), the complexity of the injury, the number of cases requiring evacuation, qualifications and number of attending personnel and the specialised equipment on board. The estimated cost per evacuation ranges from $US 8000 to $US 32,400 (Personal communication DV, Israel Air Force 22 October 2024).

By the end of December 2023, SMC had a capacity of 262 rehabilitation beds to meet the rising rehabilitation needs following the MCI. The costs of establishing an extra 122 rehabilitation beds included adapting existing geriatric rehabilitation wards to novel rehabilitation wards for a younger population. These changes included minor renovations, e.g. enlarging the dining room and lounge areas and refurbishing the patio to allow patients to spend recreation time both indoors and outdoors with an expected high number of visitors. The primary financial investment covered additional staff for medical, nursing, rehabilitation, administration, cleaning, and maintenance (Table 4). Documented policies and procedures ensured rehabilitation patients were part of a safe, appropriate, accountable, effective and measurable process. Rehabilitation services were delivered to patients by a multidisciplinary team with appropriate skills and training[26] with patients encouraged to participate in daily physiotherapy (PT) and occupational therapy (OT) sessions; indeed, those with multiple amputations or spinal cord injuries often received more than one PT or OT session per day including physiotherapists, occupational therapists, hydrotherapists, psychologists, speech pathologists, and dietitians . In-house transportation costs increased for inpatients to visit specialist doctors located within the hospitalisation tower outpatient clinics, and hydrotherapy treatments.

Nursing and allied health professional expenses encompassed a wide range of essential medical equipment and resources to support patient care and rehabilitation. These included nursing trolleys for efficient bedside care, foot pumps to aid circulation and to prevent deep vein

Table 3
Expansion of The Sheba Medical Center Integrative Rehabilitation Hospital following the MCI in October 2023.

Expansion of SMC Integrative Rehabilitation Hospital			
Rehabilitation Ward	Number of beds prior to 10 October 2023	Additional beds	Total Number of beds by 24 December 2024
Orthopaedic	40	6	46
Neurological	38	4	42
Head Trauma	42	0	42
Respiratory	20	4	24
Novel Rehabilitation Wards	0	108	108
Total Number Rehabilitation beds	140	122	262

Key: SMC – Sheba Medical Centre.

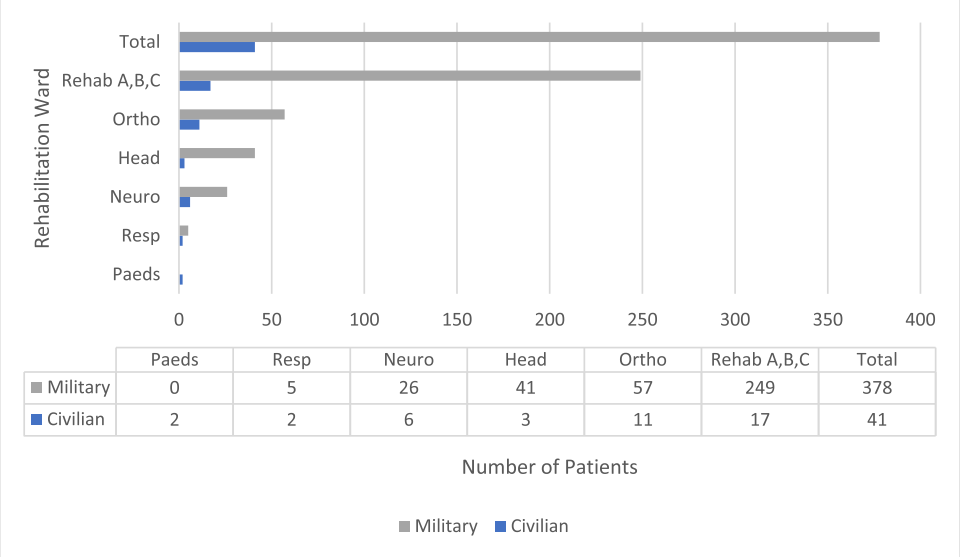


Fig. 3. The wounded patient distribution in rehabilitation wards at Sheba Medical Center from 7 October 2023 until 30 April 2024; including military, civilian and total patient numbers. *Key: Rehab A, B, C – newly designated rehabilitation wards, Ortho – Orthopaedic, Head – Head Trauma, Neuro – Neurological, Resp – Respiratory, Paeds –Paediatrics.*

Table 4
Sheba Medical Center additional full-time equivalent rehabilitation staffing requirements approved January-June 2024.

Additional Rehabilitation Hospital Staff (full-time equivalent positions)					
Role	Respiratory Ward 4 additional beds	Orthopaedic Ward 6 additional beds	Neurological Ward Pain Rehabilitation	Rehab wards A, B, C 108 additional beds	Total position
Physician	-	-	-	6	6
Nurse	6.8	4.5	0.5	3.8	15.6
Physiotherapy	-	0.8	-	9.3	10.1
Occupational Therapy	0.5	0.5	-	9	10
Hydrotherapy	0.25	-	-	0.75	1
Psychologist	0.5	0.5	-	4	5
Speech Pathologist	0.5	-	-	0.5	1
Social Worker	0.25	-	-	2	2.25
Dietician	-	0.2	-	1.25	1.45
Secretary	-	-	-	0.5	0.5
Cleaner	-	-	-	4	4
TOTAL Additional full-equivalent positions	8.8	6.5	0.5	41.1	56.9

Key: SMC- Sheba Medical Center; - represents nil.

thrombosis, and vacuum-assisted closure (VAC) systems for advanced wound management. Additional electrocardiogram (ECG) patient monitoring equipment ensured continuous cardiac assessment, while various consumable supplies supported routine medical procedures.

Therapeutic devices such as transcutaneous electrical nerve stimulation (TENS) units provided pain relief, and continuous passive motion (CPM) machines facilitated joint recovery. Mobility aids, including wheelchairs, walkers, and crutches, enabled patient ambulation, enhancing independence and rehabilitation outcomes. Additionally, investments were made in innovative technology (Fig. 4) to optimize healthcare delivery and streamline patient management. Funding was required for occupational therapy motor and cognitive skill training for orthopaedic and neurological injuries. These included MYRO® Upper limb functional therapy equipment which combines motor therapy and cognitive rehabilitation, electronic parallel bars with digital height display to support amputees whilst gait training, and an innovative Hydrotherapy Pool Ninja Gym enabling military personnel wounded at peak performance to return to high intensity exercises. A flexible budget for the rehabilitation hospital was spent on Virtual Reality (VR) technology and included the replacement of projectors and VR maintenance costs for 5 years. Medical equipment expenses included a substitute electromyography-muscle evaluation assessment instrument, a bronchoscope and ten portable computers on stands.

Expenses and funding were planned for 2025–6 to include the purchase of physiotherapy motor skill training equipment. This included a neurological rehabilitation tool, Hocoma Andago® V2.0, that allowed physiotherapists to safely perform over-ground gait and balance training via a free-moving mobile-gait robotic device combined with a body weight support system.

In addition, integrated adapted driving lessons and simulations for both civilians and military personnel with upper and lower extremity amputations or neurological deficits were included in the rehabilitation program to facilitate renewal of patient driving licences.

Hydrotherapy was an essential aspect of the rehabilitation process. Aside from scheduled individual hydrotherapy rehabilitation sessions, an experienced therapist, a water polo coach by profession, initiated a therapeutic group-swimming program 45 min in duration, five days per week. Although these sessions were extra-curricular, attendance was high (over 20 % of those wounded). These participants potentially benefitted from the social interaction provided by group swimming[27].

Speech pathologists were responsible for evaluating the audiological effects of GSWs and BIs by conducting hearing tests and linking the results to neurological and vascular injuries. Special attention was given to understanding the patterns and levels of hearing loss after GSW and BI injuries due to their potential for more severe and extensive damage compared to blunt trauma.

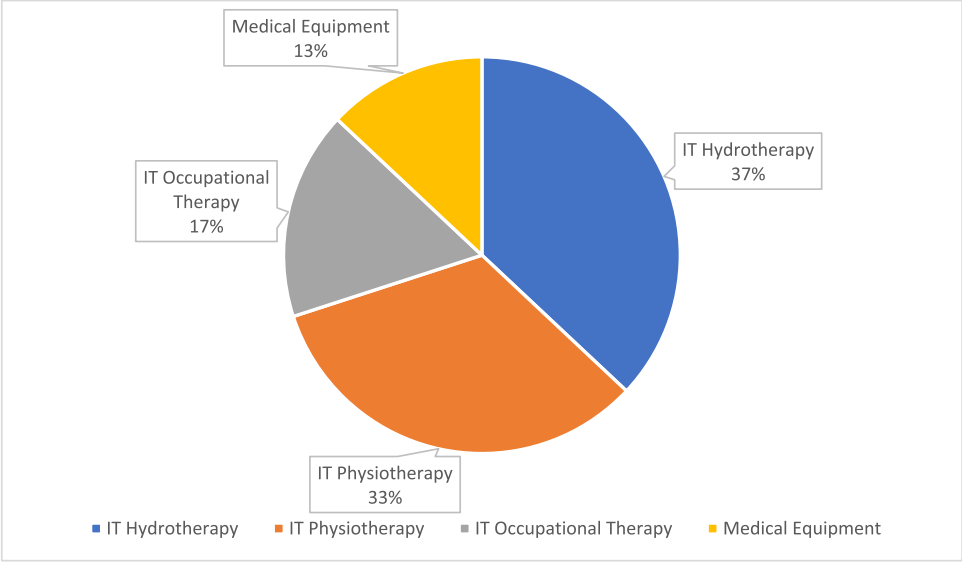


Fig. 4. Relative proportion of Sheba Medical Center approved purchase budgets for additional rehabilitation innovative technology 2024 by type of equipment. *Key: IT – Innovative Technology*.

GSW and BI patients are at a significantly higher risk for developing mental health disorders when compared to other types of traumas[28]. Psychological interventions were implemented to reduce post-traumatic stress, anxiety, and depression for both civilian and military personnel. Social workers engaged with a broader community of patients, families, and friends, offering professional support to improve mental health.

The data in Table 4 indicates the additional full-time equivalent (FTE) positions required to provide care for the influx of patients following the October 2023 MCI (N.B. 0.01 FTE would approximately equate to an hour of treatment time).

In response to the MCI, an in-kind contribution was provided by an extensive volunteer program. . Retired doctors, physiotherapists, occupational therapists, and other professionals contributed their time to support patient rehabilitation. Adapted sports such as cycling, boxing, and archery became popular among patients, with volunteers actively involved in facilitating these activities. . Afternoon/evening entertainment was also on offer to further enhance the supportive, inclusive environment.

Length of stay (LOS)

The Israeli Health System inpatient hospital stay costs are covered for all Israeli citizens by a national insurance scheme. LOS was used as a proxy for cost of stay and represents the number of days patients received inpatient rehabilitation in five different rehabilitation units at SMC over a period of three years from 2022–2024. From the dates included in Fig. 5, the tally is over 12 months for 2022, and 2023, but only over 10 months for 2024 (to October 2024). LOS varied with patient diagnoses and ranged between 2–50+ days. Factors affecting LOS included patient's social circumstances and treatment complexity.

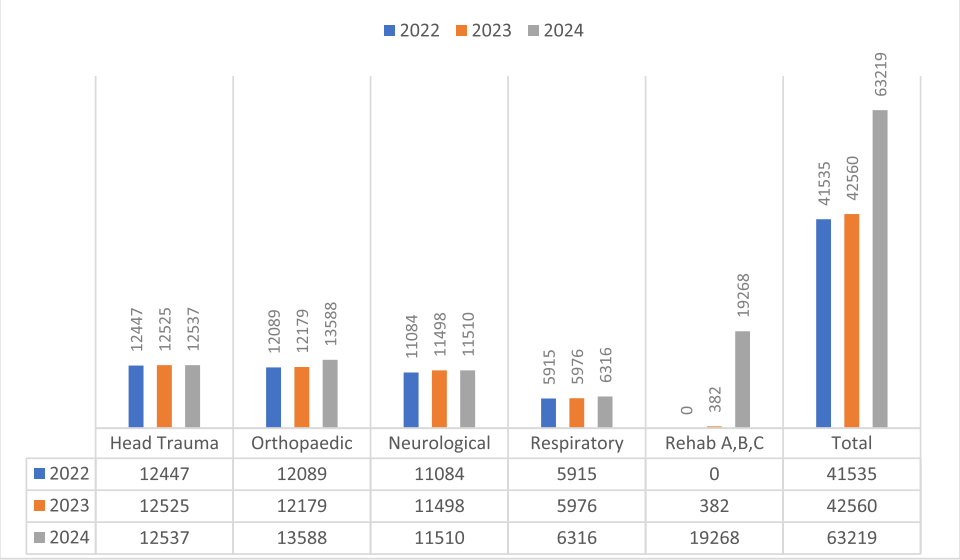
The Head Trauma rehabilitation department's total number of hospitalisation days (THD) increased slightly from 12,447 days in 2022 (12 months) to 12,537 days in 2024 (10 months). Similarly, the neurological rehabilitation's THD rose from 11,084 days in 2022 to 11,510 days in 2024. The orthopaedic rehabilitation ward's THD increased from 12,089 days in 2022 to 13,588 in 2024 (11.6 %) following the October 2023 MCI, whilst the respiratory rehabilitation ward experienced a rise from 5915 days in 2022 to 6316 THDs in 2024 (5.7 %). A notable surge was recorded in the newly established rehabilitation wards with a total number of hospitalisation days rising from 382 days between October and December 2023 to 19,268 days from January to December 2024. Overall, the total LOS across all rehabilitation departments at SMC increased from 41,535 days in 2022 to 42,560 days in 2023 and 63,219 days in 2024 (10-month period). A 2.5 % rise from 2022 to 2023 was possibly due to the additional beds made available in the existing rehabilitation wards and the 48.5 % increase from 2023 to 2024 was possibly due to the newly opened rehabilitation wards (Fig. 5).

Outpatient rehabilitation

In 2024, the Chief Executive Officer at SMC implemented a "zero waiting time plan" ensuring continuous rehabilitation care for patients transitioning from inpatient to outpatient services for military personnel and civilians. The ambulatory services provided included physiotherapy (6.4 %), occupational therapy (upper extremity and hand care treatments) (36 %), amputee clinics (19 %), hydrotherapy (31 %), and others, which included burns, pain and post-traumatic stress disorders treatment clinics (7.6 %) (Fig. 6). A new outpatient day-care unit was launched in September 2024 (staffing and equipment has been accounted for in earlier results). From September to December 2024 (81 workdays), this day-care centre delivered 824 patient days of healthcare, five days per week from 08:00 – 19:00.

Discussion

This study presents a unique analysis of inpatient and outpatient rehabilitation needs following a major MCI at SMC, Israel's Central National Trauma Centre. By utilising EMRs, we were able to analyse the rehabilitation journey of 419 patients with GSWs and BIs, admitted for rehabilitation from 7 October 2023 until 30 April 2024. Our findings underscore the significant increase in resource demands following an MCI and provide valuable insights for enhancing future preparedness and response strategies to such events. The pre-hospital response time and modes of evacuation are of great importance in MCIs[29]. According to Israeli Ministry of Health data, 1457 people who were wounded were evacuated to hospitals during the first day of the MCI, the mortality rate was low, only 2.9 % of those admitted alive[30]. Most of the early-evacuees suffered from complex injuries including high-velocity GSW, BI from rocket-propelled grenades, and burns. Many would later require complex surgeries by all disciplines including general surgeons, vascular surgeons, orthopaedic surgeons, neurosurgeons, cardiothoracic surgeons, otolaryngologists, oral maxillofacial surgeons, and plastic



	Head Trauma	Orthopaedic	Neurological	Respiratory	Rehab A,B,C	Total
2022	12447	12089	11084	5915	0	41535
2023	12525	12179	11498	5976	382	42560
2024	12537	13588	11510	6316	19268	63219

Fig. 5. Total length of hospitalisation stays (number of days) per year (2022, 2023, 2024,) of all inpatients admitted to the different rehabilitation departments at Sheba Medical Center between: January 2022 until October 2024. *Key: Rehab A, B, C – newly designated rehabilitation wards.*

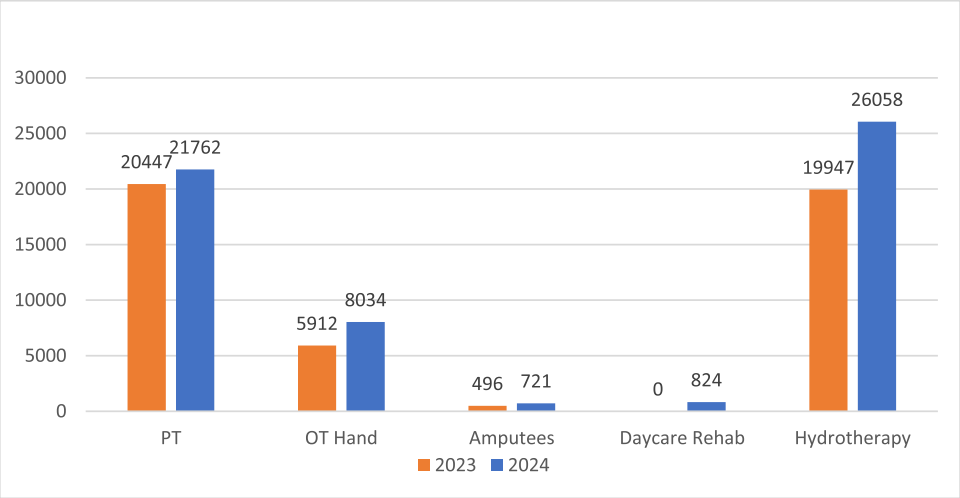


Fig. 6. Total number of outpatient clinical rehabilitation days provided by the different outpatient clinics at Sheba Medical Center 2023–2024. *Key: PT – physiotherapy, OT – occupational therapy; Rehab – Rehabilitation.*

surgeons[31].

Civilians and military personnel showed different patterns of injury with civilians experiencing significantly greater GSW whilst military personnel experienced greater BI. The admission to rehabilitation wards (Fig. 3) also varied with 84 % military and 16 % civilians in the orthopaedic wards and 94 % military and 6 % civilians in the novel designated rehabilitation wards. Overall, each ward had a greater percentage of military personnel than civilians; which may have resulted from the initial transfer of civilians from place of injury to other local hospitals and priority transfer of critically injured military personnel directly to SMC.

Injuries sustained from the October MCI were predominantly GSWs. In the subsequent six months, there was a shift from mostly GSWs to a combination of GSWs and BIs, highlighting the dynamic nature of MCI mechanism of injury patterns[32]. As demonstrated by SMC, effective management relies on pre-hospital and hospital care competency, which is heavily influenced by a robust national trauma system[33]. SMC's capability to manage a significant surge in patient volume, exceeding its standard operational capacity (medical surge capacity)[34], illustrates its preparedness. However, our data emphasise the critical need for a four-pronged approach to MCI preparedness: systems, space, staff, and supplies[35–37].

The rapid expansion of rehabilitation services, including the establishment of three novel designated rehabilitation wards, highlights SMC's ability to adapt swiftly to evolving demands. However, this growth necessitated a substantial financial investment, with personnel costs rising by 30 %, infrastructure by 13 %, and IT by 11 %. The increased LOS from 2023 to 2024 (Fig. 5) in key wards—most notably a 5.5 % increase in orthopaedic rehabilitation and a significant 96 % rise in the novel rehabilitation wards, underscores the severity and complexity of patients' injuries. These cases require comprehensive multidisciplinary rehabilitation, encompassing physiotherapy, occupational therapy, speech therapy, and psychological support. Compared to GSW patients, the higher costs associated with BI patients further highlights the differences in healthcare resource implications from various injury mechanisms[38]. These financial considerations should be balanced against the long-term benefits of comprehensive rehabilitation, such as improved functional recovery and reduced long-term disability[39]. Furthermore, the high utilisation rate of outpatient rehabilitation services (Fig. 6), especially among motivated young military personnel, underscores the importance of providing a smooth transition from inpatient to outpatient care.

While Israel's healthcare system generally provides high-quality services at relatively lower costs than those in the US or Europe[40, 41], this MCI unveiled significant staffing challenges. The temporary absence of military medical personnel and a shortage of allied health professionals underscore the need for robust staffing plans that address potential personnel shortages during MCIs. The substantial contribution of volunteer staff highlights the capacity to utilise community resources in times of emergency.

The strengths of this study arise from its unique access to EMR data following a significant MCI at a leading trauma centre. EMR data analysis provided a patient-centred, multidisciplinary view of rehabilitation services. Limitations include the retrospective design and the possibility of inconsistencies in EMR data recording, particularly under the pressures of a MCI event. Future prospective studies are required to validate these findings and further explore the cost-effectiveness of specific interventions.

Conclusion

This study reveals significant resource demands and operational challenges associated with rehabilitating patients after a large-scale MCI. SMC's experience highlights the importance of proactive planning, adequate funding, strategic resource allocation, and multidisciplinary collaboration to ensure effective and efficient rehabilitation services. Investing in staff, advanced technologies, and expediting smooth transitions from inpatient to outpatient care is essential for optimising patient outcomes and maintaining operational capacity during future emergencies. The data underscore the need for ongoing investment in trauma care infrastructure and personnel to ensure national readiness for similar events. The high proportion of military personnel wounded emphasises the necessity of integrating civilian and military healthcare systems for an optimal response to MCIs.

Ethics in publishing statement

I testify on behalf of all co-authors that our article submitted followed ethical principles in publishing. All authors agree that: This research presents an accurate account of the work performed, all data presented are accurate and methodologies detailed enough to permit others to replicate the work. This manuscript represents entirely original work and or if work and/or words of others have been used, that this has been appropriately cited or quoted and permission has been obtained where necessary. This material has not been published in whole or in part elsewhere. The manuscript is not currently being considered for publication in another journal. Generative AI and AI-assisted technologies have not been utilized in the writing process and have not been used

to create or alter images. All authors have been personally and actively involved in substantive work leading to the manuscript and will hold themselves jointly and individually responsible for its content.

CRediT authorship contribution statement

C Barmatz: Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **M Crowe:** Writing – review & editing, Visualization, Supervision, Methodology, Conceptualization. **E Biros:** Writing – review & editing, Software, Formal analysis. **D Mendez:** Writing – review & editing, Visualization, Supervision, Methodology, Conceptualization. **I Dudkiewicz:** Writing – review & editing. **JE Reznik:** Writing – review & editing, Visualization, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of personal interests

CB: Director of Hydrotherapy, ID: Head of the Rehabilitation Division, JR, EB: honouree positions, SMC

CB: (PhD candidate), JR: (Primary Advisor), MC: (Advisor Mentor), DM (Secondary Advisor), EB: (Secondary Advisor), ID: (Clinical Advisor), JCU, Queensland, Australia

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