

Rates of Missed Injuries in the Prehospital Setting Are Unrelated to the Gender of the Medical Provider: A Retrospective Study

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ABSTRACT **Background:** Medical organizations worldwide aim for equity and diversity in the medical profession. While associations between the caregiver gender and treatment outcomes in hospitals have been previously studied, data on the prehospital setting are scarce.

Objective: To analyze the rates of missed injuries in the prehospital setting and determine whether these rates were associated with the gender of the on-field physician or paramedic.

Methods: A retrospective record review was conducted, which included trauma records documented in two trauma registries, the prehospital Israel Defense Forces-Trauma Registry (IDF-TR), and the in-hospital Israeli National Trauma Registry (INTR). Missed injuries were defined as injuries documented in the INTR but not in the IDF-TR. A multivariable regression analysis was performed to assess the association between provider's gender and missed injuries.

Results: Of 490 casualties, 369 (75.3%) were treated by teams that included only male paramedics or physicians. In 386 (78.8%) cases, a physician was a part of the prehospital team. In all, 94 (19.2%) casualties sustained injuries that were missed by the prehospital medical team. Missed injuries were not associated with the gender of the paramedic or physician (odds ratio 1.242, 95% confidence interval 0.69–2.193).

Conclusions: No association was found between the gender of the medical provider in the prehospital setting and the rate of missed injuries. These results should encourage prehospital emergency medical systems to aim for a balanced and diverse caregiver population.

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KEY WORDS: missed injuries, military medicine, paramedic gender, physician gender

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Medical organizations worldwide strive for equality and diversity among medical professionals [1]. According to the data released by the Association of American Medical Colleges in 2019 [2], women comprised the majority of enrolled U.S. medical students. Female physicians and paramedics in the Israel Defense Forces (IDF) and other military organizations have been increasingly integrated into combat units, destined to treat casualties in the prehospital tactical setting. Nevertheless, a recent publication from the United States showed that female medical providers remained underrepresented in emergency medical services [3]. Cumulative evidence supports the notion that medical outcomes have not been affected by the gender of the physicians, paramedics, or other medical professionals. Moreover, equality and diversity among caregivers improved quality [4] and allowed medical professionals to fulfill their trauma caregiver tasks. A better understanding of potential differences (or the lack of them) based on caregiver gender is valuable for integrating an increasing number of female physicians and paramedics in military and civilian health systems and trauma care teams. Although information concerning the caregiver gender in the hospital setting has been previously published [4], data on whether this issue affects outcomes in the prehospital setting are scarce [5].

The initial assessment of trauma casualties consists of primary and secondary surveys. These surveys were designed to aid timely diagnosis of potentially life-threatening traumatic injuries [6], subsequently determining the proceeding treatment and evacuation protocols [7].

Undiagnosed injuries during the initial evaluation of trauma casualties, especially during the critical prehospital phase, may lead to trauma casualty mismanagement and thus cause preventable morbidity and mortality [8,9]. Although it is anticipated that some injuries will be missed during this primary evaluation, it is important to determine the scale and impact of missing injuries to understand how trauma protocols affect casualties. Moreover, only those injuries that were detected can be further classified as

life threatening or not; therefore, it is important to minimize the missed injuries rates. While several studies have evaluated the rate of missed injuries [6,9-14] only a few were able to compare prehospital and in-hospital registries to evaluate the rate of missed injuries prior to arrival at the hospital. This rate was shown to affect medical outcomes and has been previously used as a measure for quality of care [9,11]. Data on the association between caregiver gender and missed injury rates in the prehospital setting are unavailable to the best of our knowledge. The aim of the study was to assess the rate of missed injuries in the Israel Defense Forces-Medical Corps (IDF-MC) among hospitalized casualties; as well as to determine whether the gender of the on-field physicians or paramedics was associated with rates of missed injuries in the prehospital setting.

PATIENTS AND METHODS

The IDF-MC ethics board approved this study. A retrospective record review of two trauma registries—the IDF trauma registry (IDF-TR) and the Israeli National Trauma Registry (INTR)—was performed.

IDF MILITARY MEDICAL TEAMS

The IDF-MC trains medical teams to provide optimal prehospital care. These teams provide point of injury (POI) care and enroute care in both civilian and military events. The teams consist of a general physician, or alternatively a paramedic trained in advanced life support (ALS), as well as two or three combat medics. These care providers undergo designated trauma courses in the IDF school of military medicine that focus on in-field medical care protocols and training. Medevac teams aid in treatment and evacuation when needed. These teams include one specialist physician (anesthesiology, critical care, surgery, or emergency medicine) and one paramedic or another physician supplemented by three to six combat medics or surgical and anesthesia specialists. During high-intensity conflicts and warfare, additional military medical teams participate in the treatment and evacuation of casualties.

THE IDF-TRAUMA REGISTRY

The IDF-Trauma Registry (IDF-TR) is a prehospital trauma registry for recording data on POI care by IDF medical teams [15]. Entries in the IDF-TR are a product of both patient casualty cards, which are completed by IDF teams before the patient evacuation, as well as information recorded by the treating physician or paramedic using a web-based application. The data are submitted within 72 hours of the injury. After that, it is validated by the IDF's Trauma and Combat Medicine Branch to ensure consistency and accuracy. The IDF-TR includes records of all trauma casualties treated by IDF medical teams and records of injured soldiers treated by civilian medical teams. The latter were retrospectively recorded by military personnel.

ISRAELI NATIONAL TRAUMA REGISTRY

The INTR is a hospital-based trauma registry utilized by most trauma centers in Israel, including all six level 1 centers. The registry contains data on patients who were admitted to a hospital due to traumatic injuries as classified by ICD-9-CM codes. Data are submitted by hospital trauma registry teams and undergoes review and quality assurance by hospital trauma directors and the National Center for Trauma and Emergency Medicine Research. This registry does not include patients who were not hospitalized.

STUDY POPULATION AND DATA EXTRACTION

The study was based on records of casualties from 2006 to 2017 documented on both registries (therefore only hospitalized cases). Soldiers and civilians were treated by IDF medical teams during this period in a wide variety of prehospital settings and injury scenarios. Hence, the study population consisted of patients injured in military events (combat, training, terror attacks) and non-military events (e.g., motor vehicle accidents, falls, recreational injuries, criminal conflicts). A computerized search was utilized to collect patient data (e.g., age, sex), injury data (e.g., anatomic location, injury severity score [ISS], scenario, and mechanism of injury), number of casualties per event, and caregiver data (number of medical team members, number of medical teams per event, and the gender of the paramedics and physicians on field). Overall trauma severity was classified by ISS, and a score of 16 or higher was considered severe. A rigorous exclusion process excluded all low-quality record entries (where significant data were missing), and all records between 2006 and 2013 that did not include the prehospital paramedic or physician gender [Figure 1].

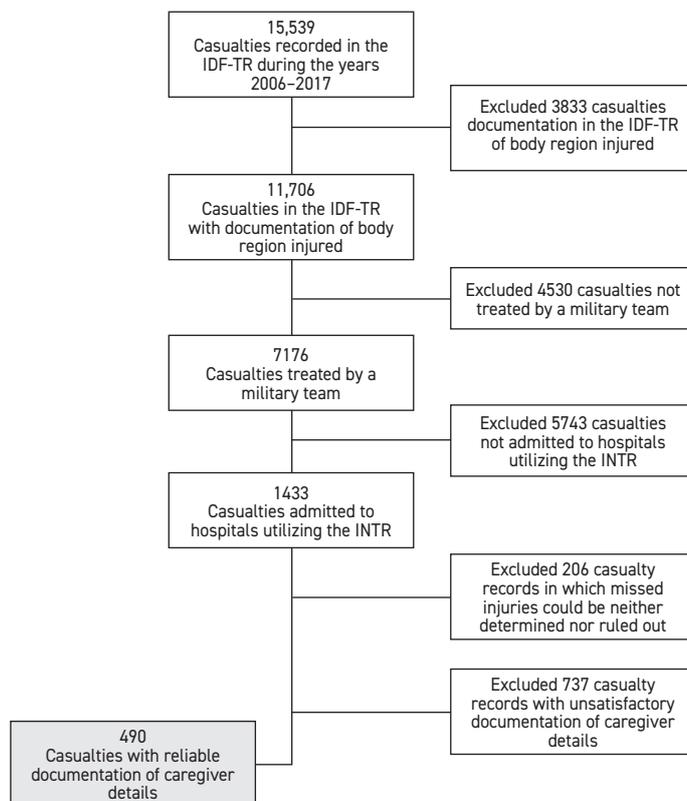
Data from the IDF-TR were compared with data from the INTR using state-issued identification number, patient injury date, and admission for record matching. Missed injuries were defined as injuries documented on the INTR but not on the IDF-TR. Because we compared body regions involved according to both registries, we also excluded casualties with prehospital documentation of unknown body region injured, indicating low documentation quality. Following the computerized search, a single researcher (NSK) manually reviewed each record defined as missed to verify that an injury was missed by the military medical team rather than just poorly documented [Figure 1] or cases in which the authors were not certain whether injuries had been missed or not were excluded. Ultimately, the study included 490 records with full and reliable documentation. Patient, injury, and caregiver characteristics were then analyzed and compared between the two groups.

STATISTICAL ANALYSIS

Data analysis was performed using R version 3.6.0 (R Core Team, Vienna, Austria). A post-hoc power analysis showed that given the study population size and assuming a missed injury rate of 20% among medical teams that did not include a female caregiver, this study was powered ($\beta = 0.8$) to find a difference of 13.4%. Descriptive statistics were used to present raw data. We presented cat-

Figure 1. Exclusion process

IDF-TR = Israel Defense Forces-Trauma Registry, INTR = Israeli National Trauma Registry



egorical variables with rates and included means and standard deviations with range for continuous variables. Categorical variables were compared using Fisher's exact test. Continuous variables were compared using the non-parametric Mann-Whitney test. Multivariable logistic regression analysis was performed. In this analysis, missed injuries were set as the dependent variable, modeled against independent variables that were clinically significant or found to be statistically significant on the univariable analysis. The former variables were chosen a priori as variables that were either the focus of the current study or were assumed to have a possible effect on the management on field: primary caregiver gender, casualty population type (civilian or military personnel), primary caregiver qualification (physician or paramedic), injury scenario (motor vehicle accident, fall from height, gunshot injury, other), military/non-military activity related event, team/casualties ratio, and parameters that represented injury severity and casualty state, including systolic blood pressure < 90 mmHg and ISS category (9–14, 16–24, ≥ 25). Since no additional statistically significant independent variables were found on the univariable analysis, this compilation was eventually the list of variables that were included in the multivariable model. Statistical significance was defined by P -value ≤ 0.05 .

RESULTS

During the study period 15,539 records of trauma casualties were documented in the IDF-TR. Following the exclusion process, a total of 490 casualties were included in the study [Figure 1]. Characteristics of casualties treated by the IDF medical teams, comparing teams with or without a female ALS provider, are presented in Table 1. The teams (sometimes a few teams at a single event) included a mean of 6.1 ± 3.8 (range 1–14) members. In all, 386 (78.8%) of the casualties were treated by teams where a physician was the most qualified medical caregiver. Of the total 490 cases, 369 (75.3%) were treated by teams that did not include a female paramedic or physician. During the study period, the rate of traumatic events treated by a medical team that included a female paramedic or physician had been constantly growing and reached 51.4% in 2017. Medical teams that included a female caregiver were less likely to have a physician as the most qualified caregiver in the team ($P < 0.001$). Most casualties had an ISS score of 1 to 14 ($n=400$, 81.6%).

Of all casualties, 94 (19.2%) sustained injuries that were further classified as missed injuries. Medical teams that did not include a female primary caregiver had a slightly lower rate of missed injuries, although this difference was statistically insignificant: 64 (17.3%) vs. 30 (24.7%) for teams without and with a female primary caregiver respectively, $P = 0.083$.

The univariable and multivariable logistic regression analyses of the association of various factors with missed injuries are presented in Table 3. These analyses revealed that the gender of ALS providers was unassociated with the odds of missed injuries (odds ratio [OR] 1.242, 95% confidence interval [95%CI] 0.69–2.193 in the multivariable model). The odds of missed injuries were found to be higher in motor vehicle accident (MVA) related injuries (OR 5.378, 95%CI 2.266–13.157), when casualties outnumbered team members (OR 1.966, 95%CI 1.074–3.638), and when ISS scores were higher than 15 (OR 2.3, 95%CI 0.984–5.14). The odds for missed injuries were lower in casualties with gunshot wounds (OR 0.362, 95%CI 0.117–0.929).

DISCUSSION

For this study, we implemented a unique utilization of the largest Israeli prehospital [15] and in-hospital trauma registries and offered an analysis of the prehospital missed injuries rate. No association between the caregiver gender and the rate of missed injuries was found. Equality among medical caregivers is an essential cornerstone in medical organizations and modern societies. It has been previously suggested that diversity among caregivers does not only allow professionals of all genders to fulfill their potential but can also improve the quality of medical care [3]. Following the increasing integration of female caregivers in all fields of medicine it is now possible to study how and if the caregiver's gender

Table 1. Characteristics of casualties treated by the IDF medical teams, comparing teams with or without a female physician/paramedic

Variable		Only male providers on team (n=369, 75.3%)	Female medical provider on team (n=121, 24.7%)	Total (n=490)	P value
Casualty gender	Male	359 (97.3%)	113 (93.4%)	472 (96.3%)	0.048
	Female	10 (2.7%)	8 (6.6%)	18 (3.7%)	
Casualty age in years, mean ± standard deviation, (range)		23.2 ± 6.6 (14–73)	23.9 ± 7.5 (16–64)	23.4 ± 6.8 (14–73)	0.558
Casualty population	Civilian	31 (8.4%)	14 (11.6%)	45 (9.2%)	0.295
	Soldier	338 (91.6%)	107 (88.4%)	445 (90.8%)	
Scenario	Motor vehicle accident	46 (12.5%)	31 (25.6%)	77 (15.7%)	0.003
	Fall from height	26 (7.0%)	9 (7.4%)	35 (7.1%)	
	Gunshot	70 (19.0%)	17 (14.0%)	87 (17.8%)	
	explosion	165 (44.4%)	38 (31.4%)	203 (41.4%)	
	Other	62 (16.8%)	26 (21.5%)	88 (18.0%)	
Team members/casualties ratio	≥ 1	249 (67.5%)	99 (81.8%)	348 (71.0%)	0.003
	<1	120 (32.5%)	22 (18.2%)	142 (29.0%)	
Distribution of physicians and paramedics in the IDF teams	2014	249 (83.0%)	51 (17.0%)	300 (100.0%)	< 0.001
	2015	62 (69.7%)	27 (30.3%)	89 (100.0%)	
	2016	41 (62.1%)	25 (37.9%)	66 (100.0%)	
	2017	17 (48.6%)	18 (51.4%)	35 (100.0%)	
Systolic blood pressure	< 90	7 (1.9%)	4 (3.3%)	11 (2.2%)	0.628
	≥ 90	354 (95.9%)	115 (95.0%)	469 (95.7%)	
	Unknown	8 (2.2%)	2 (1.7%)	10 (2.1%)	
Injury Severity Score	1-14	308 (83.5%)	92 (76.0%)	400 (81.6%)	0.116
	16-24	33 (8.9%)	11 (9.1%)	44 (9.0%)	
	25+	28 (7.6%)	18 (14.9%)	46 (9.4%)	
Glasgow Comma Scale	9–15	338 (91.6%)	109 (90.1%)	447 (91.2%)	0.159
	3–8	22 (6.0%)	11 (9.1%)	33 (6.7%)	
	unknown	9 (2.4%)	1 (0.8%)	10 (2.0%)	
Hospitalization duration, days	1–6	269 (72.9%)	84 (69.4%)	353 (72.0%)	0.484
	7+	100 (27.1%)	37 (30.6%)	137 (28.0%)	
ICU admission		60 (16.3%)	25 (20.7%)	85 (17.3%)	0.271
Discharge	Home	305 (82.7%)	92 (76.0%)	397 (81.0%)	0.232
	Rehabilitation	56 (15.2%)	27 (22.3%)	83 (16.9%)	
	Died	8 (2.2%)	2 (1.7%)	10 (2.0%)	

ICU = intensive care unit

influences different treatment aspects in a variety of fields in medicine, including prehospital trauma care, offering feedback for policy makers. By having the opportunity to compare prehospital and in-hospital trauma registries, we can reliably assess prehospital missed injury rates and add valuable data to the existing literature.

The impact of the gender of the caregiver on the medical care and outcomes has been previously studied. In the hospi-

tal setting female and male surgeons who treated individuals of similar characteristics obtained similar outcomes [4,16-19]. In a study on 125,787 patients who were operated by lumbar or cervical spinal fusion, none of the demographic characteristics of the surgeons, including gender, was found to be associated with surgical outcomes [18]. Data that compared outcomes between male and female caregivers in the prehospital setting

Table 2. Missed injuries in trauma casualties treated by the IDF medical teams, comparing teams with or without a female physician/paramedic

Variable	Only male providers on team (n=369)	Female provider on team (n=121)	Total cohort (n=490)	P value
Any body region	64 (17.34%)	30 (24.79%)	94 (19.18%)	0.083
Head and neck*	42 (65.6%)	17 (56.6%)	59 (62.7%)	0.425
Trunk*	59 (92.2%)	23 (76.6%)	82 (87.2%)	0.483
Lower extremities*	49 (76.6%)	23 (76.6%)	72 (76.6%)	0.139
Upper extremities*	24 (37.5%)	10 (33.3%)	34 (36.2%)	0.537

*The denominator is the number of casualties with any body region missed in the group

Table 3. Univariable and multivariable logistic regression analysis for the outcome of missing an injury

Analysis		Unadjusted			Adjusted		
Variable		OR	95%CI	P value	OR	95%CI	P value
Female paramedic or physician on team		1.571	0.951–2.556	0.072	1.242	0.69–2.193	0.461
Casualty population (civilian)		2.316	1.164–4.448	0.013	1.217	0.485–3.01	0.671
Most qualified team member	Paramedic	1.272	0.721–2.174	0.391	0.905	0.44–1.806	0.736
	MVA	3.866	2.179–6.906	< 0.001	5.378	2.266–13.157	< 0.001
Scenario	Fall from height	1.374	0.546–3.159	0.472	2.209	0.748–6.148	0.137
	Gunshot	0.283	0.094–0.687	0.011	0.362	0.117–0.929	0.050
	Other	0.595	0.268–1.218	0.175	0.784	0.324–1.778	0.573
Non-military events		1.495	0.901–2.439	0.112	0.558	0.238–1.242	0.164
SBP < 90		1.044	0.051–8.505	0.970	1.117	0.048–11.648	0.931
Team/casualty ratio < 1		1.602	0.992–2.562	0.051	1.966	1.074–3.638	0.029
ISS	9–14	1.310	0.711–2.346	0.373	1.314	0.687–2.444	0.397
	15–24	2.516	1.187–5.117	0.013	2.3	0.984–5.14	0.047
	≥ 25	4.615	2.352–9.007	< 0.001	3.308	1.543–7.06	0.002

95%CI = 95% confidence interval, OR = odds ratio, MBA = motor vehicle accident, SBP = systolic blood pressure, ISS = Injury Severity Score

are scarce. In this setting no association was found between the paramedic gender and analgesic administration [5], pain reduction level [20], and the use and application of a triage scale [21]. On training, male gender was associated with deeper chest compressions during basic life support simulations [22]. When tested for their physical fitness, female paramedics had slower performance time than that of male paramedics but were still able to meet the physical employment standards required for the paramedic's work [23], which implied the insignificance of this difference on their skills as primary caregivers. We were not able to find additional published studies that evaluated the impact of the caregiver gender on the medical treatment in the prehospital setting, including missed injuries.

Missed injuries have been previously found to have an impact on medical outcomes and have been used as a measure for quality of care [8,9,11]. Missed injuries have been commonly defined as injuries that were not identified during the primary and secondary

surveys, only to be later detected during the tertiary survey [8,9]. However, the definitions of missed injuries described in the literature were highly variable, as are the study populations and methodologies in different analyses. In a review of 16 studies, Pfeifer and Pape [8] found a reported incidence rate of 1–39%, of which approximately 15–22% were clinically significant. Additional studies have found the rates of missed injuries to range from 2–25% among different study groups over the past decade [10,11,24]. Researchers have also found that missed injuries were associated with higher injury severity scores [9,10] and increased mortality [6,14]. This study demonstrated that injured patients involved in MVAs were more likely to have a missed injury when compared with other injury scenarios [14]. Healthcare providers should be alerted to the higher rates of missed injuries among casualties involved in MVAs and conduct a thorough history and physical examination with the highest level of suspicion when treating these casualties.

In this study, the prehospital settings total missed injury rate

was found to be alarmingly high (19.2%). Understanding the ramifications of missed injuries on morbidity and mortality is vital toward measuring their impact on patients. An autopsy-based study found that missed injuries may account for up to 6.5% of injury-related mortality [25]. Emet and colleagues [13] found that patients with missed injuries had a significantly higher mortality rate and more extended hospital stay. Giannakopoulos et al. [9] did not find that patients with missed injuries had an increased mortality rate. However, a higher ISS was associated with missed injuries in such patients [9]. Considering the latter, the mere presence of significant trauma injuries might predispose to missing injuries, since a major injury can have a distractive effect. A literature review from 2011 concluded that missed injuries might not have led to higher mortality rates but were associated with major distracting injuries that were readily identified and increased mortality rate [12]. Measuring the actual clinical impact of missed injuries on morbidity and mortality remains challenging, as these often occur in conjunction with other significant injuries.

LIMITATIONS

This study had several limitations. As we conducted a retrospective record review, we were obliged to rely on documentation from other caregivers. Furthermore, the use of two separate registries composed of entries from different caregivers might have caused misinterpretations of clinical data that the researchers could not detect. The ability to manually curate and review each record might have decreased the significance of this limitation. The study timeframe was too short for estimating trends in the missed injuries rates. Moreover, since only hospitalized patients were included, our findings represent this specific population rather than the entire casualty population treated by the IDF-MC. Most paramedics and physicians in this study were male, and most injuries were sustained in military-related events. Therefore, it might be difficult to generalize the findings for civilian prehospital medical systems. The statistical analysis aimed to detect differences in rates of missed injuries but could not have completely rule out any mild association with the paramedic or physician gender.

CONCLUSIONS

We did not find an association between the gender of physicians and paramedics in the prehospital setting and missed injuries rates. Considering the struggle for equality and diversity in the medical profession in the modern era; the findings should encourage prehospital emergency medical systems to aim for a balanced and diverse caregiver population.

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