Transport time after combat-related injury and patient-reported outcomes among US service members

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Received 22 May 2020
Revised 21 December 2020
Accepted 27 December 2020
Published Online First 22 January 2021

ABSTRACT

Introduction The '*golden hour*' is a universal paradigm that suggests trauma patients have lower morbidity and mortality when provided with medical care within 1 hour after injury. The objective of this study was to examine whether transport time from point of injury to a military treatment facility (MTF) in-theatre was associated with patient-reported outcomes, such as post-traumatic stress disorder (PTSD), depression and quality of life (QOL), among US service members with combat-related injury.

Methods Participants were injured between March 2003 and March 2016 and completed standardised assessments of PTSD, depression and QOL for theWounded Warrior Recovery Project (WWRP) between January 2013 and November 2017. Multivariable regressions were used to assess the relationship between transport time (≤1 hour or >1 hour from injury to MTF) and positive screens for PTSD and depression, and QOL, respectively.

RESULTS

Overall, 45.6% of participants (n=879) arrived at an MTF within 1 hour postinjury. About 8 years passed between when participants were injured on deployment and when they completed their first WWRP assessment. Approximately 48% of participants screened positive for PTSD and 51.3% for depression, with a mean QOL score of 0.513 (SD=0.150). After adjusting for covariates, transport time was not significantly associated with PTSD (OR 1.04, 95% CI 0.79 to 1.38; p=0.77), depression (OR 0.92, 95% CI 0.69 to 1.21; p=0.55) or QOL (β=0.009; p=0.38).

Conclusion Transport time was not associated with patient-reported outcomes among US service members with combat-related injury. These findings are important as we seek to understand how combat casualties may be affected by extended medical evacuation or transport times anticipated in future expeditionary operations.

Key messages

⇒ Medical treatment within the '*golden hour*' after traumatic injury is known to improve immediate morbidity and mortality outcomes.
⇒ Adverse mental health outcomes, particularly post-traumatic stress disorder and depression, and lower quality of life have been reported among service members injured on combat deployment.
⇒ Transport time from injury to military treatment facility within the golden hour was not associated with long-term mental health and quality of life outcomes.
⇒ These findings should be considered in light of future expeditionary operations that may have extended transport times.

INTRODUCTION

In emergency medicine, the '*golden hour*' refers to the initial 60 min time frame after traumatic injury, during which prompt medical treatment can optimise survival.[1] This paradigm emerged as a function of improved military trauma triage methods, which reduced prehospital transport time from 10 hours in World War II to 1 hour in the Vietnam conflict.[2] Military and civilian studies found improved morbidity and mortality outcomes as a function of medical care received within the golden hour, which suggests a necessity for prehospital medical treatment and emphasises the criticality of expedited transport times from injury to treatment facility.[3 4]

In 2009, in light of the abovementioned findings, the Department of Defence mandated that wounded troops be transported from the battlefield to a military treatment facility (MTF) within 1 hour after trauma. A recent study by Kotwal *et al*[2] found that the case fatality rate declined after this '*golden hour policy*' was enacted. Furthermore, the case fatality rate and frequency of those killed in action were significantly higher among those transported to care after the first hour of injury relative to those transported to care within the hour of injury. They also found there was a greater reduction of acute morbidity among those critically injured who were transported within rather than outside the golden hour.[2] A recent panel of experts from the UK Defence Medical Services reiterated the importance of expedient delivery of care with the consensus being that prolonged holds at forward field hospitals could pose both logistical and clinical difficulties in future conflicts and may contribute to increases in morbidity and mortality, particularly holds greater than 8 hour.[5]

Overall, case fatality rates diminished during Operations Enduring and Iraqi Freedom relative to previous conflicts, which may be explained by reductions in medical response times, as well as technological developments in protective equipment and improvements in medical treatments.[6] Consequently, service members with combat-related

To cite: Hawari RJ, McCabe CT, Dougherty AL, *et al*. *BMJ Mil Health* 2023;**169**:e34–e38.

injuries are surviving at higher rates than in previous conflicts, but experience higher rates of chronic pain and other physical and mental health disorders.[7] In addition to worsened mental health, particularly post-traumatic stress disorder (PTSD) and depression, poor quality of life (QOL) has been reported among individuals injured on combat deployment.[8] QOL is characterised as an overall measurement to capture a person's dynamic psychological, physical, social and spiritual aspects of life.[9]

Many of the problems faced by injured service members (eg, decreased QOL, mental health symptoms) are subjective in nature and require assessment of patient-reported outcomes. Unlike other indicators of objective health, patient-reported outcomes provide insight into an individual's health status by capturing their self-reported experience of symptoms and status, which cannot be obtained from objective tests or records.[10] Patient-reported outcomes have also demonstrated relationships with medical care in other health domains, such as pain management.[11] Although evidence suggests that treatment within the golden hour is related to reduced morbidity and mortality,[2] less is known about how rapid transit to medical care following traumatic injury relates to long-term patient-reported outcomes.

The objective of the present study was to explore the association between transport time or time from point of injury to arrival at first documented MTF in theatre and long-term patient-reported outcomes (ie, PTSD, depression and QOL) among a sample of US service members with combat-related injury. We hypothesised that individuals who arrived at an MTF within the first hour postinjury would have lower odds of screening positive for PTSD and depression and report higher levels of QOL compared with those who arrived at an MTF more than 1 hour postinjury.

METHODS

Participants

Data from the present study were obtained from the Wounded Warrior Recovery Project (WWRP), a 15-year longitudinal examination of patient-reported outcomes among service members injured during combat deployment.[12] Eligible participants for the WWRP were identified from the Expeditionary Medical Encounter Database (EMED), a US Navy-maintained deployment health database that includes tactical, clinical and personnel encounter data of service members from post-9/11 overseas contingency operations.[13] The WWRP began recruiting in November 2012 and has recruited more than 5300 service members as of November 2017. Recruitment and data collection are ongoing. Additional details concerning the WWRP and EMED methodology are available elsewhere.[12 13]

The study population obtained from the WWRP included 1120 participants with transport time information available in the EMED. Participants whose first documented level of care was at a Role 1, 2 or 3 facility were included in the analysis. Role 1 facilities are equipped to stabilise and triage patients or prepare them for evacuation to a higher level of care. Role 2 and 3 facilities have more advanced capabilities for medical and surgical intervention, with Role 3 facilities providing the most advanced level of care within a combat zone. Participants with more severe injuries requiring evacuation out of theatre (Role 4) or to the Continental United States (Role 5) (n=8) were excluded because minimum evacuation times to first level of care exceeded 1 hour. One participant was excluded because their Injury Severity Score (ISS) was missing, and 68 participants were excluded due to missing transport time information. Lastly, to address whether expedient transport to medical care within the golden hour was associated with better long-term outcomes than longer transport times, 164 participants were excluded with either outlier transport times or a transport time greater than 24 hours. The final study sample consisted of 879 participants who had a verified injury date and time, and an MTF arrival date and time. Participants were injured between March 2003 and March 2016 and completed their first WWRP online assessment between January 2013 and November 2017.

Measures

Dates and times of injury and arrival at first documented MTF in-theatre were extracted from the EMED. Transport times were calculated based on time elapsed between the dates and times of injury to arrival at an MTF, by subtracting injury date and time from MTF arrival date and time. Consistent with previous research on the golden hour, transport time from injury to MTF arrival was dichotomised as ≤1 hour or >1 hour.[2]

Sociodemographic and injury-related variables included age at survey, time from injury to survey, military rank (enlisted or officer), service branch (Army, Air Force, Marine Corps or Navy), ethnicity/race (white, Hispanic/Latino, black/African American or other/unknown), injury mechanism (blast or gunshot wound/bullet) and ISS (1–8 (minor/moderate injury) or 9+ (serious/severe injury)). The ISS is an anatomically based scoring system that calculates an overall score for trauma patients with multiple injuries and was categorised per previous literature.[14 15]

PTSD symptoms were assessed using the validated PTSD Checklist-Civilian Version (PCL-C).[16] This widely used self-report rating scale contains 17 items that track severity of PTSD symptoms over the past month. The PCL-C measures PTSD symptoms that are related to a traumatic, stressful experience. Participants rate their level of symptom severity on a scale of 1 (not at all) to 5 (extremely). Scores were summed and dichotomised, with a standardised cut-off of 44 or higher indicating a positive screening for PTSD.

Depression symptoms were assessed using the 20-item Center for Epidemiologic Studies Depression Scale, a widely used and validated depressive symptomology scale.[17] Participants report their level of depressive symptoms on a scale of 0 (rarely/none of the time) to 3 (most/all of the time) over the past week. Total scores are summed and range from 0 (lowest depression) to 60 (highest depression). A standardised cut-point of 16 or greater was applied, indicating a positive screen for depression.

QOL was evaluated using the Quality of Well-being Scale–Self-administered (QWB-SA), a preference-weighted measure capturing physical and mental health functioning, status and condition over the past 3 days.[18] The QWB-SA has been widely used in studies with injured service members, civilians and veterans.[19–21] The proprietary scoring algorithm[18] provides a point-in-time estimate of one's physical functioning and QOL, with scores that range from 0 (death) to 1 (asymptomatic functioning).

Statistical analysis

Statistical analyses were conducted in SAS V.9.4 (SAS Institute). Descriptive statistics for sociodemographic and injury-related variables by transport time were calculated using χ^2 and independent samples t-tests. Variables statistically associated with transport time were included in multivariable analyses. Multivariate logistic and linear regressions were used to examine the association between transport time and screening positive for PTSD and depression, and QOL scores, respectively, adjusting for age, time (years) from injury to completion

Table 1 Demographic and injury-specific characteristics of the study sample by transport time

	Transport time			
	Total (n=879)	≤1 hour (n=401)	>1 hour (n=478)	P value
Mean (SD) age at survey (years)	34.0 (6.4)	34.4 (6.3)	33.7 (6.5)	0.10
Mean (SD) time from injury to survey (years)	7.7 (3.3)	8.0 (3.1)	7.6 (3.4)	0.06
Male, no (%)	856 (97.4)	388 (96.8)	468 (97.9)	0.29
Rank, no (%)*				0.24
Enlisted	783 (92.7)	364 (94.3)	419 (91.3)	
Officer	62 (7.3)	22 (5.7)	40 (8.7)	
Service branch, no (%)				0.05
Army	365 (41.5)	182 (45.4)	183 (38.3)	
Air Force	7 (<1)	1 (<1)	6 (1.3)	
Marine Corps	460 (52.3)	201 (50.1)	259 (54.2)	
Navy	47 (5.3)	17 (4.2)	30 (6.3)	
Ethnicity/race, no (%)†				0.06
White	666 (77.5)	297 (76.7)	369 (78.2)	
Hispanic/Latino	110 (12.8)	45 (11.6)	65 (13.8)	
Black/African American	47 (5.5)	27 (7.0)	20 (4.2)	
Other/unknown	36 (4.2)	18 (4.6)	18 (3.8)	
Injury mechanism, no (%)‡				0.003
Blast	743 (84.6)	328 (81.8)	415 (87.0)	
Gunshot wound/bullet	91 (10.4)	57 (14.2)	34 (7.1)	
Other	44 (5.0)	16 (4.0)	28 (5.9)	
Injury Severity Score, no (%)				<0.001
1–8	681 (77.5)	269 (67.1)	412 (86.2)	
9+	198 (22.5)	132 (32.9)	66 (13.8)	

Note: Because of rounding, percentages may not total 100.
*n=845; missing data for 34 participants were excluded from analysis.
†n=859; missing data for 20 participants were excluded from analysis.
‡n=878; missing data for 1 participant was excluded from analysis.

of the WWRP assessment, injury mechanism and ISS. Additionally, because qualitative differences may exist in the availability of medical care at each level of care (ie, Role 1, Role 2, Role 3), these models were then stratified to explore whether these associations differed based on the first documented level of care. An alpha level of 0.05 was used to determine statistical significance.

RESULTS

Descriptive statistics on sociodemographic and injury-related characteristics by transport time are displayed in Table 1. Study participants (n=879) were about 34 years old (SD=6.4) when they completed their first WWRP assessment. Approximately 8 years lapsed between when participants were injured on deployment and completion of their first WWRP assessment (SD=3.3). Most participants were men (97.4%), non-Hispanic, white (77.5%), enlisted (92.7%) and served in the Army (41.5%) or Marine Corps (52.3%). Overall, 45.6% of participants arrived at an MTF within 1 hour after injury. Most (77.5%) sustained minor or moderate injuries, and 84.6% were injured by a blast. Nearly half of participants (48.2%) screened positive for PTSD and 51.3% screened positive for depression. The average QWB-SA score assessing QOL was 0.513 (SD=0.150). For context, QWB-SA scores were lower than those previously reported among US outpatient medical samples.[22]

As shown in table 1, bivariate comparisons revealed participants with transport times greater than 1 hour were more likely to be in the Marine Corps, whereas those with transport times less than 1 hour were more likely to serve in the Army (p=0.05). In addition, those with transport times greater than 1 hour were more likely to be injured in a blast (p<0.01) and had less severe injuries overall (p<0.001) relative to those with transport times less than 1 hour. After adjusting for these covariates, transport time was not statistically associated with PTSD (OR 1.04, 95% CI 0.79 to 1.38; p=0.77), depression (OR 0.92, 95% CI 0.69 to 1.21; p=0.55) or QOL (β=0.009; p=0.38) (table 2). In supplemental analyses (data not shown), these associations were unchanged when stratified by the first documented level of care.

DISCUSSION

To our knowledge, this study is the first to examine the relationship between transport time to medical treatment after traumatic injury and long-term patient-reported outcomes. Contrary to our hypotheses, transport time from the point of injury to first documented MTF within the first hour postinjury was not associated with lower odds of PTSD and depression symptoms or higher QOL among service members with combat-related injury. This suggests that while transport from injury to medical care within the golden hour optimises immediate morbidity and mortality outcomes,[2] long-term patient-reported outcomes may not be similarly affected. Although the results did not support our hypotheses, it is potentially reassuring that increased transport time was not associated with worsened long-term mental health and QOL outcomes. The findings of this study are important,

Table 2 Multivariable logistic and linear regression models for transport time and post-traumatic stress disorder (PTSD), depression and quality of life (QOL)

	PTSD* (N=862)		Depression* (N=863)		QOL† (N=862)	
Characteristic	OR (95% CI)	P value	OR (95% CI)	P value	β	P value
Transport time‡						
≤1 hour	Ref		Ref		Ref	
>1 hour	1.04 (0.79 to 1.38)	0.77	0.92 (0.69 to 1.21)	0.55	0.009	0.38
Age at survey	1.00 (0.98 to 1.02)	0.89	1.00 (0.98 to 1.03)	0.71	−0.002	0.01
Time from injury to survey	1.02 (0.98 to 1.07)	0.27	1.03 (0.99 to 1.07)	0.19	0.002	0.13
Injury mechanism						
Blast	Ref		Ref		Ref	
Gunshot wound/bullet	0.72 (0.45 to 1.14)	0.16	0.86 (0.55 to 1.36)	0.53	0.031	0.07
Other	0.89 (0.48 to 1.65)	0.72	1.07 (0.58 to 1.98)	0.82	−0.017	0.47
Injury Severity Score						
1–8	Ref		Ref		Ref	
9+	0.73 (0.52 to 1.03)	0.07	0.70 (0.50 to 0.99)	0.04	−0.033	0.01

*Multivariate logistic regression, adjusted by age at survey, time from injury to survey, injury mechanism and Injury Severity Score.
†Multivariate linear regression, adjusted by age at survey, time from injury to survey, injury mechanism and Injury Severity Score.
‡Supplemental analyses were conducted to determine whether longer transport times were associated with outcomes by categorising those participants with transport times >1 hour into 1–6 hours or >6 hours. Results were unchanged.

but should be interpreted with caution, as we seek to understand how casualties may be impacted by extended medical evacuation or transport times anticipated for future expeditionary operations.

It is important to note that participants completed the WWRP assessment an average of 8 years after combat-related injury. Considering this timeline, it is plausible that more proximal, unmeasured factors that occurred between injury and the WWRP assessment could have an impact on mental health and QOL above and beyond factors related to initial medical treatment (eg, transport time). For example, certain health behaviours among service members may help (eg, physical activity, healthful diet)[23] or hinder (eg, excessive alcohol consumption, cigarette use)[24 25] health and well-being. In addition, interpersonal factors such as social support[26] and social integration[27] or intrapersonal factors such as hardiness and resilience[28] may have direct impacts on mental health and QOL. Continued multidisciplinary research is needed to better understand factors that contribute to the health and readiness of service members injured on combat deployment to ensure optimal recovery from injury.

This study has limitations that warrant mention. First, transport times were calculated based on the first documented medical record with injury and arrival dates and times recorded in the EMED. It is possible that participants arrived at another MTF prior to the documented MTF, which may have led to an overestimation of transport times in some cases. In addition, this analysis also did not include assessment of prehospital medication(s) (ie, medication administered before arriving at an MTF), which may differentially affect treatment outcomes. Research suggests that analgesic medications, such as morphine, may inhibit the development of PTSD following serious combat injury.[29] Future studies on transport time and patient-reported outcomes should account for prehospital medications.

Despite the limitations, this study has notable strengths, specifically the use of the WWRP and EMED. The WWRP utilises standardised and well-validated assessment tools to measure PTSD, depression symptoms and QOL. The EMED is a comprehensive and unique data set that includes medical information for in-theatre MTFs, including injury and arrival dates and times that allows for the calculation of transport times in combat theatre.

CONCLUSION

The present study found that transport time was not statistically associated with long-term patient-reported outcomes, including PTSD, depression and QOL, among service members with combat-related injury. These findings should be considered in light of future expeditionary operations that may have extended transport times. As we seek to understand the long-term effects of combat-related injury, future studies should evaluate how other proximal factors such as medication administration and types of medical treatments received within the golden hour are related to patient-reported outcomes.

Correction notice This article has been corrected since it first published. The provenance and peer review statement has been included.

Acknowledgements We recognise and thank Melanie Adams, Bree Fox and the clinical team of the Medical Modeling, Simulation and Mission Support Department for their support in validating participant clinical records, and current and past Wounded Warrior Recovery Project team members and students for their work on the WWRP.

Contributors RJH and CTM designed the study. JRW, JS and MG acquired the data. RJH, SLE and CTM analysed the data. All authors interpreted the data. RJH, CTM and AD drafted the manuscript. SLE, JRW, JS and MG critically revised the manuscript for important intellectual content. All authors approved the version to be published and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Funding This research was supported by the US Navy Bureau of Medicine and Surgery under work unit no 60808.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval Naval Health Research Center Institutional Review Board.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available. The datasets generated and/or analysed during the current study are not publicly available due to personally identifiable information regulations, but may be made available by the corresponding author on reasonable request and approval by the Naval Health Research Center Institutional Review Board.

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