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HAS THE SUN SET ON THE GOLDEN HOUR?

by

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September 2020

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The golden hour rule—the belief that trauma patients are more likely to survive if they receive definitive care within sixty minutes of sustaining an injury—has shaped the U.S. military's medical and operational strategies since 2009 and perhaps longer. The objective of this study was to explore the effectiveness of the golden hour as a strategic guideline for saving lives in combat operations and to compare it to the use of Tactical Combat Casualty Care (TCCC) and damage control surgical teams located at the forward edge of combat operations. A detailed review of data on the survivability of wounded servicemembers and civilians proved that there is no significant difference in survivability rates when the golden hour is preferred over TCCC. The 60-minute rule has been promoted based on opinion, anecdote, and incomplete data rather than evidence-based practice. This study opposes the continued use of the golden hour rule as an operational metric and instead proposes that U.S. military combat health support doctrine stresses TCCC proficiency and mobile surgical intervention closest to the most likely point of injury.

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HAS THE SUN SET ON THE GOLDEN HOUR?

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requirements for the degree of

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ABSTRACT

The golden hour rule—the belief that trauma patients are more likely to survive if they receive definitive care within sixty minutes of sustaining an injury—has shaped the U.S. military's medical and operational strategies since 2009 and perhaps longer. The objective of this study was to explore the effectiveness of the golden hour as a strategic guideline for saving lives in combat operations and to compare it to the use of Tactical Combat Casualty Care (TCCC) and damage control surgical teams located at the forward edge of combat operations. A detailed review of data on the survivability of wounded servicemembers and civilians proved that there is no significant difference in survivability rates when the golden hour is preferred over TCCC. The 60-minute rule has been promoted based on opinion, anecdote, and incomplete data rather than evidence-based practice. This study opposes the continued use of the golden hour rule as an operational metric and instead proposes that U.S. military combat health support doctrine stresses TCCC proficiency and mobile surgical intervention closest to the most likely point of injury.

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LIST OF ACRONYMS AND ABBREVIATIONS

AOR	area of responsibility
CJOA	combined joint operational area
CJOA-A	Combine Joint Operational Area-Afghanistan
CSH	combat support hospital
DCR	damage control resuscitation
DCS	damage control surgery
DOW	died of wounds
EMS	emergency medical services
FST	forward surgical team
GHOST-T	golden hour offset surgical transport team
GSW	gunshot wound
HEMS	helicopter emergency medical services
KIA	killed in action
MEDEVAC	medical evacuation
OAFME	Office of the Armed Forces Medical Examiner
ODA	Operation Detachment Alpha
SOCM	special operations combat medic
SOF	special operations forces
SOST	special operations surgical team
SORT	Special Operations Resuscitation Team
TBI	traumatic brain injury
TCCC	Tactical Combat Casualty Care
WIA	wounded in action

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I. INTRODUCTION

There is a popular belief that trauma patients are more likely to survive if they receive definitive care—which is defined as treatment capable of handling all injuries, regardless of the severity or level of acuteness[1]—within sixty minutes of the time the injury was sustained. This notion is often called the *golden hour*, and is a foundational concept of the tiered civilian trauma treatment center system in the United States. Although there is no large body of conclusive evidence to support this sixty-minute standard, sometimes called the 60-minute rule or golden hour rule, it is nonetheless widely accepted that there is a relationship between patient survivability and the speed at which patients receive definitive care.

In June 2009, with credence to the golden hour concept and a belief that combat-wounded servicemembers would gain potential lifesaving benefits from the reduced time between injury and appropriate treatment, then Secretary of Defense Robert M. Gates mandated a "golden hour standard" policy for the Combined Joint Area of Operations–Afghanistan (CJOA-A).[2] Though never formally codified as military doctrine, this policy and related concepts have evolved into a standard rule for all combat operations, including in current and future combat deployment areas.

A. RESEARCH QUESTION

The purpose of this thesis is to challenge the unquestioned standard, and ask: Can the sixty-minute evacuation standard be offset by individual warfighter proficiency in Tactical Combat Casualty Care and employment of mobile resuscitative care elements? Additionally, this thesis examines the practicality and applicability of the sixty-minute standard of evacuation to future operations and makes recommendations for further studies concerning applicable changes in operational planning and execution. The thesis also

[1] "Definitive Care Facilities," American College of Surgeons, September 4, 2017, https://www.facs.org/media/files/quality%20programs/trauma/hospitallevels.ashx.

[2] Robert M. Gates, *Duty: Memoirs of a Secretary at War* (New York: Random House; 2014), 305–06.

examines how battlefield medical care and evacuation have evolved, and highlights how the golden hour policy was devised and implemented. Additionally, it discusses the results and outcomes of the rule's 2009 enforcement on military operations in Afghanistan, which is essential for understanding its current usage and applicability.

B. SIGNIFICANCE OF THE RESEARCH QUESTION

The U.S. military is currently trying to balance active participation in two theaters of conflict along with preparation for the inevitable future of warfare. It is probable, too, that the operational landscape of future conflict will be one that the U.S. military has yet to face. As the Army Training and Doctrine Command states:

> Potential adversaries now possess capabilities that allow them to contest both the deployment and employment of U.S. forces in greatly expanded areas of operation, interest, and influence. U.S. forces are not organized, trained, equipped, and postured to contest emerging and potential threats properly. As a result, the freedom of action required to support U.S. policy, by deterring, and if necessary, defeating potential enemies is at risk.[3]

To address these challenges, the U.S. military has already begun a shift toward smaller, more self-sufficient elements, which it has employed in areas of the world that have proven to be austere, remote, resource-depleted, and resupply-restrictive.[4] These environments have made it impossible for medical rescue teams to adhere to the sixty-minute evacuation standard; it is both impractical and sometimes downright impossible. A blanket golden hour policy, which has become accepted as doctrine, requires significant financial resources and brings with it a set of specific and undeniable risks. Specifically, adherence to the rule requires extensive human resources, expensive medical equipment, and highly specialized professionals to be aggregated, mobilized, and deployed throughout the areas of operation. Additionally, the rule necessitates large amounts of real estate in

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[3] U.S. Army Training and Doctrine Command, "Multi-domain Battle: Combined Arms for the 21st Century" (white paper, U.S. Army, February 24, 2017), http://www.tradoc.army.mil/multidomainbattle/docs/MDB_WhitePaper.pdf.

[4] Megan Myers, "Milley: Future Conflicts Will Require Smaller Army Units, More Mature Soldiers," *Army Times*, March 21, 2017, http://www.armytimes.com/news/your-army/2017/03/21/milley-future-conflicts-will-require-smaller-army-units-more-mature-soldiers.

size and number and updates to current and new infrastructure, and it will also require well-established ground maneuverability along with air superiority, all of which will most likely be absent from future areas of operation. For the Department of Defense's medical community to continue providing world-class combat health support to these units, it must adapt to changes in the norm of operational environments.

This thesis examines strategic use of the golden hour against a different standard: warfighter proficiency in Tactical Combat Casualty Care and the employment of small, mobile, and scalable resuscitative surgical teams. This alternative is a patient-focused model that may provide the best and most life-saving combat casualty care to deployed servicemembers. If applicable, this concept could allow medical teams to capitalize on the immediate lifesaving window of opportunity for an injured patient much closer to the fighting force in a more conducive, less risky, and less resource-intensive manner.

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II. LITERATURE REVIEW

A. THE SIXTY-MINUTE WINDOW OF OPPORTUNITY

Before we can question the applicability and practicality of the sixty-minute window of evacuation for U.S. military forces, we must first understand the background of the concept and how it became so commonplace within the American military. During the Battle of Antietam, Army surgeon Dr. Jonathan Letterman first realized that the faster front-line casualties were moved to an aid station in the rear, the greater chance they had at surviving their injuries. At the time when even minor injuries could result in death, this was novel.[5] The concept quickly gained traction as Letterman demonstrated to leadership a drastic increase in troop survivability through the employment of ambulance teams and aid stations closer to the front lines.[6] His ingenuity and direct impact on survivability rates through these newfound practices earned him the nickname "the father of battlefield medicine," and it has since been understood that the faster a trauma patient is evacuated to appropriate treatment, the higher the likelihood of survival.[7] The operational environments that U.S. servicemembers have encountered have transformed significantly since the Civil War, yet one factor remains the same: minimizing the amount of time that elapses between a significant injury and arrival at definitive is both a tenet and a benchmark of the military's combat health support system.[8]

The military witnessed a significant reduction in the died-of-wounds (DOW) rate of trauma casualties sustained in Korea and Vietnam through the use of rotary-wing

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[5] "Major Johnathan Letterman," Civil War Trust: Savings America's Civil War Battlefields, Accessed March 1, 2017, http://www.civilwarmed.org/quick-facts/letterman.

[6] Civil War Trust.

[7] Civil War Trust.

[8] Russ S. Kotwal et al., "The Effect of a Golden Hour Policy on the Morbidity and Mortality of Combat Casualties," *The Journal of the American Medical Association Network* 151, no. 1 (Jan 2016): 15-24, https://doi.org/10.1001/jamasurg.2015.3104.

evacuation.[9] Thanks to the range and speed of rotary-wing aircraft, patient movement times decreases from ten hours in the Second World War to five hours during the Korean War, and finally to just an hour in Vietnam.[10] With each reduction in transport time, a lesser DOW rate followed. These observations, combined with his own experiences as a military surgeon, led R. Adams Cowley to establish the Shock Trauma Center of Baltimore and a patient air evacuation system. The Shock Trauma Center was based entirely around design concepts of U.S. Army field surgical hospitals, and the air transport system was built on police rotary-wing platforms that mimicked medical evacuation operations in Vietnam.[11] Cowley went on to coin the term *golden hour* to refer to the "time period lasting for 60 minutes, or less, following traumatic injury being sustained by a casualty, during which there is the highest likelihood that prompt medical treatment will prevent death."[12]

B. EVOLUTION OF BATTLEFIELD INJURY AND U.S. POLICY IMPLEMENTATION

Cowley's methodologies—combined with increasing troop levels, higher numbers of trauma-producing attacks on U.S. maneuver forces, and increased rates of servicemembers killed in action—led Secretary Gates to implement the golden hour in military policy. Early 2009 marked a sharp increase in not only the number of overall casualty and fatality-producing attacks on U.S. forces but also in improvised explosive device and suicide-bombing-style attacks. The number of attacks rose sharply and the

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[9] James R. Ficke et al., "Dismounted Complex Blast Injury Report of the Army Dismounted Complex Blast Injury Task Force," *Journal of Trauma and Acute Care Surgery* 73, no.6 (December 2012): S520–S534, https://doi.org/10.1097/TA.0b013e31827559da.

[10] Kotwal et al., "The Effect of a Golden Hour Policy," 15.

[11] Ronald F. Bellamy, "The Causes of Death in Conventional Land Warfare: Implications for Combat Casualty Care Research," *Military Medicine* 149, no.2 (February 1984): 55–62, https://doi.org/10.1093/milmed/149.2.55; H.R. Champion et al., "A profile of Combat Injury," *The Journal of Trauma* 54, no.5 (suppl) (May 2003): S13-S19, https://doi.org/10.1097/01.TA.0000057151.02906.27; BJ Eastridge et al., "Death on the battlefield (2001-2011): Implications for the Future of Combat Casualty Care," *Journal of Trauma and Acute Care Surgery* 73, no. 6 (suppl 5) (December 2012): S431-S437, https://doi.org/10.1097/TA.0b013e3182755dcc.

[12] American College of Surgeons, *ATLS: Advanced Trauma Life Support for Doctors (Student Course Manual)*, 8th Edition (Chicago: American College of Surgeons, 2008), 200, ISBN 978–1880696316.

traumatic injuries inflicted on U.S. forces were awe-striking.[13] The blast injuries commonly seen with these types of attacks include blunt-force trauma, brain injury, internal and external hemorrhage, and often limb loss. These are the most severe types of trauma, and the injuries to servicemembers further convinced Secretary Gates that no expense should be spared and additional risks could be accepted elsewhere if it meant lowering the DOW rate and reducing mortalities from preventable causes.[14]

By implementing this policy, Secretary Gates could not only reduce the number of deaths and conserve the fighting force but could also send a strong and clear message to the deployed military and the entire nation: our government cares about its servicemembers and is going to commit all resources necessary to ensure the best care.[15] The time period preceding Secretary Gates's mandate was marked by a high operational tempo that had unit morale levels down, and the nation had grown weary of the toll of multiple ongoing wars. While the policy's intent was mainly to put the servicemembers first, and the desire to lower mortality was genuine, it also improved the morale of those units deployed downrange, eased the minds of stressed families on the home front, and even helped fortify recruiting efforts under the common belief that our troops' lives were the foremost priority.

C. OUTCOMES OF REDUCED EVACUATION TIMES

In 2015, Dr. Russ Kotwal and his team conducted "a retrospective descriptive analysis of U.S. military combat casualties during the Afghanistan War, from September 11, 2001, to March 31, 2014, both wounded in action (WIA) and, killed in action (KIA), according to whether they occurred before or after the mandate and with other conflicts."[16] Kotwal and his team used numerous variables during their analysis, including return-to-duty rates (the proportion of wounded soldiers who made it back to combat in seventy-two

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[13] NATO ISAF, "Enemy Initiated Attacks, January 2008 – December 2008," (Presentation, Kabul, Afghanistan, NATO Headquarters, 2012), Accessed: 15 September 2017.

[14] Eric Savitsky et al., Combat Casualty Care: Lessons Learned from OEF and OIF (USA: Department of the Army, 2012), 43–83.

[15] Gates, *Duty*, 305–06.

[16] Kotwal et al., "The Effect of a Golden Hour Policy," 15.

hours), KIA and DOW rates, and case fatality rates. The scholars also included injured servicemembers who had access to helicopter evacuation services during their prehospital time. Nevertheless, those who did not succumb to severe injuries were excluded because their wellbeing was not tied to emergency transportation. Kotwal et al. went through the scene time flight data, especially the nature of wounds, launch time, aircraft call, and arrival at the emergency department. They compared autopsy records from the Armed Forces Medical Examiner with casualty data from the Department of Defense Trauma Registry.[17] The group dichotomized their data depending on whether the evacuation times lasted more or less than sixty minutes. Kotwal et al. focused on three mortality outcomes: DOW, KIA, and overall mortalities. Based on a treatment facility's acute morbidity outcomes, the four primary causes were cardiac arrest, shock, amputation, and coagulopathy. Injury and demographic-related metrics were sex, injury mechanism, age, and severity score.

The published review of their analysis, as depicted in Figure 1, concluded that helicopter evacuation shortens the prehospital time, giving injured servicemembers, some of whom could easily have died on their way to the trauma facility, access to both hospital-based and en route care. Even those who were likely to die during their earlier hours at the hospital managed to survive because they received essential surgical procedures on time. However, lower KIA mortality rates did not have a similar impact on DOW victims. Therefore, evacuation times, as well as prompt facility and en route therapy, were responsible for the higher success rate. Overall, the reduction in evacuation durations as well as practitioner capability within scene times reduced KIA mortality casualties and enabled more servicemembers to survive long enough to form part of the DOW morbidity groups. Additionally, a notable proportion of the DOW mortality categories also managed to overcome their injuries. In the end, reduced prehospital time followed by access to quality therapy options in the emergency department improved patient outcomes, even during elevated complexity and severity of wounds.

[17] Kotwal et al.

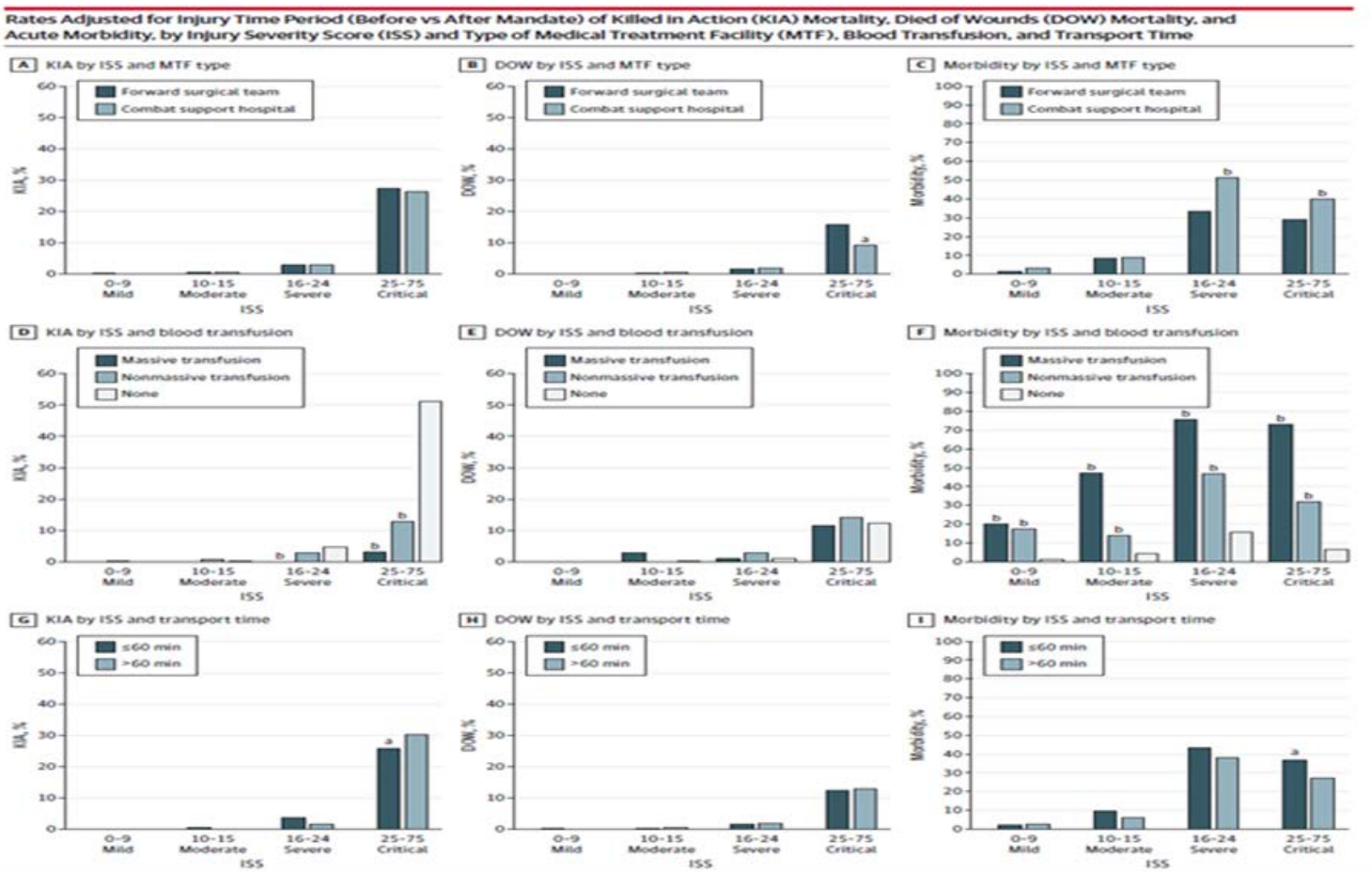

Figure 1. Results of Kotwal et al.'s Golden Hour Policy Research[18]

[18]Source: Kotwal et al., 21.

As shown in Kotwal et al.'s study, the reduction in transport time resulted in a lower KIA rate simply because the evacuated servicemembers would have died anytime after the sixty-minute window (or new forty-two-minute mean transport time), and would then no longer be classified as KIA; they would be classified as DOW, so there is no surprise that the KIA statistic dropped. However, if the golden hour theory was not effective, they would have seen an increase in the DOW rate, which they did not. The fact that the DOW rate remained unchanged means a percentage of people in the DOW group survived because they reached definitive care in time for it to make a difference.

Though Kotwal et al. determined that shortening evacuation times to definitive care does, in fact, have the propensity to save lives, the medical community should use this single study to make an overall determination about the policy's effectiveness. The data set is not perfect, nor could it probably ever be. Many factors surrounding the nature of the data used, mostly due to unavailability, are not taken into account in the team's research. For example, treatment capabilities at a Role 2 forward surgical team are damage control and resuscitative in nature, whereas a Role 3 surgical suite in a combat support hospital may have more life-saving capabilities.[19] These factors can easily skew the data. A scenario could have easily existed where a servicemember was wounded at a location on the battlefield where evacuation to only a Role 2 facility could meet the sixty-minute requirement. Said servicemember then subsequently becomes a DOW statistic because the Role 2 facility could not do enough to save his life, either due to lack of capability or capacity. However, if that same servicemember had been wounded in a location close enough to a Role 3 facility and survived because the facility had more robust capabilities, it is a completely different outcome. This is not factored into the overall determination.

An additional unknown is the time between when the servicemembers sustained their injuries and when the actual call for evacuation took place. Due to the nature of troops actively engaged in combat and the fog of war, a significant amount of time often passes between the time when a servicemember is wounded and when an official request for

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[19] U.S. Army, *The Army Health System*, FM 4-02 (ATTP 4-02) (Washington, DC: U.S. Government Printing Office, 2013), 19.

evacuation can be made. The sixty-minute timeline used in the Kotwal et al. investigation s tarts after the official call for evacuation is received. The gap in time between sustainment of trauma and request for evacuation is not considered, and could significantly impact the data determining if a deceased patient is considered KIA or DOW.

A third factor that is omitted from the investigation is all the data sets of patients who are ground evacuated to definitive care. The intent of the investigation, though focused on rotary-wing evacuation, was to determine whether or not the sixty-minute standard reduced mortality rates. The number of evacuations that took place via ground transportation both within and outside the sixty minutes from injury is unknown, but should play a significant role in the evaluation. It was commonplace in Combined Joint Area of Operations–Afghanistan during the timeframe Kotwal et al.'s data collection for patients that were within a sixty-minute drivable distance to definitive care to be evacuated by wheeled vehicle. None of the survivability numbers from those evacuations are used in the analysis and conclusion that the policy is effective. The medical community cannot know at this time how that data would have affected the result of the investigation and, without it, the argument for Kotwal et al.'s conclusion is weakened.

Finally, one of the most critical factors detracting from Kotwal et al.'s conclusion is that, with the exception of a few particular situations, the medical providers who contributed data could never truly know that a patient who reached definitive care within sixty minutes, and ultimately survived, would not have survived if their time from injury to treatment had exceeded sixty minutes. There are certainly some specific instances where a provider could determine that if, for instance, had a hemorrhage not been controlled or shock not treated promptly, the patient would not have survived. However, for a majority of the trauma survivors, the medical community has no way to know if a patient would have lived or died had the sequence of their treatment gone differently. There are simply no grounds for the claim to be made that patients who survived would not have survived if their access to care fell outside the sixty-minute window.

Even further evidence to question Kotwal et al.'s investigation can be found in a study conducted by Dr. Craig Newgard et al. called "Emergency Medical Services Intervals and Survival in Trauma: Assessment of the 'Golden Hour' in a North American

Prospective Cohort." In this in-depth analysis, 3,656 trauma patients that died either en route or once they arrived at definitive care were analyzed to determine whether the time of evacuation to care affected survivability. Their methodology involved an examination of outpatients aged no less than 15 years who were suffering from trauma. The victims made it to the hospital on time due to the assistance they received from emergency medical services (EMS) organizations. This investigation took place between 2005 and 2007. Some of the factors the scholars used to determine inclusion include systolic blood, Glasgow Coma Scale, and respiratory rate. Based on their analysis, they concluded there was not a conclusive relationship between EMS intervals and mortality.[20]

Newgard et al.'s research used a much larger population and took into consideration many more factors than the Kotwal et al. investigation, many of which included the aforementioned gaps in the Kotwal et al. study. With this information, we can infer that there may be too many variables at play to make an official determination of the validity of Secretary Gate's policy. It was perhaps said best by E. Brooke Lerner and Ronald Moscati in "The Golden Hour: Scientific Fact or Medical 'Urban Legend'?"; the authors postulate that medical practitioners should rely on "evidence-based data to determine the efficacy of the Golden Hour rule before widely adopting it as an unquestioned standard."[21] As researchers seek to improve the quality of services that the health care industry offers, they should also ensure that all their principles have a solid logical foundation.[22]

D. POINT OF INJURY TREATMENT

Tactical Combat Casualty Care, or TCCC, is a set of routinely updated prehospital trauma care guidelines that are geared for use in combat scenarios; they are based on lessons learned and best practices from the joint services and are monitored by a

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[20] Craig D. Newgard et al., "Emergency Medical Services Intervals and Survival in Trauma: Assessment of the 'Golden Hour' in a North American Prospective Cohort," *Annals of Emergency Medicine* 55, no. 3 (2010): 235–46, https://doi.org/10.1016/j.annemergmed.2009.07.024.

[21] E. Brooke Lerner and Ronald M. Moscati, "The Golden Hour: Scientific Fact or Medical 'Urban Legend'?" *Academic Emergency Medicine* 8, no. 7 (July 2001): 758–60, https://doi.org/10.1111/j.1553-2712.2001.tb00201.x.

[22] Lerner and Moscati, 760.

committee.[23] TCCC was first developed in the mid-1990s based on special operations platforms' experiences, and it has subsequently become a standard for all combat medical personnel for conducting battlefield combat health support. Proficient TCCC practices are alone responsible for a dramatic reduction in preventable death across a wide spectrum of military operations.[24]

TCCC is continuously updated based on user input, and regular amendments to its practicing guidelines are made as the nature of operations and injuries change, but also as advancements in technology, medical equipment, and trauma care are made in real time.[25] TCCC is currently taught as a multiday, multiphase course in San Antonio, Texas, and other locations throughout the Department of Defense, with specific the specific purpose of training combat medical personnel for deployment conditions.

TCCC has been battlefield-proven and was the sole driving force behind the reintroduction and widespread deployment of individual soldier training on the proper use of tourniquets for battlefield hemorrhage control, which has saved hundreds of lives and limbs.[26] Specifically, the "TCCC-led use of tourniquets in the U.S. Military caused the incidence of death from extremity hemorrhage to drop from the 7.8% incidence noted by Kelly early in the wars—which was essentially the same as in Vietnam—to 2.6% of the total combat fatalities by the end of 2011—a 67% decrease in deaths from this cause."[27] Additionally, when drilling down into specific data sets of 75th Ranger Regiment and their noted successes of TCCC use, Kotwal et al. show that the Rangers implement a program called the Ranger First Responder program, which mandated all Rangers were to be trained

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[23] "Tactical Combat Casualty Care," National Association of Emergency Medical Technicians, Accessed 5 September, 2017, https://www.naemt.org/education/naemt-tccc.

[24] National Association of Emergency Medical Technicians.

[25] Frank K. Butler, "Two Decades of Saving Lives on the Battlefield: Tactical Combat Casualty Care Turns 20," *Journal of Special Operations Medicine* 17, no. 2 (2017): 166–172, https://doi.org/10.7205/MILMED-D-16-00214.

[26] Butler, 166.

[27] BJ Eastridge et al., "Death on the Battlefield (2001-2011): Implications for the Future of Combat Casualty Care," *Journal of Trauma and Acute Care Surgery* 73, no. 6 (suppl 5) (2012): S431-S437, https://doi.org/10.1097/TA.0b013e3182755dcc.

and proficient in TCCC. When put into practice under combat conditions, "the Ranger Regiment achieved the lowest rate of preventable death in any recorded period of wartime."[28] It is with the data revealed in these studies—and with further investigation, particularly regarding hemorrhage control and stabilization—that the tactics taught in TCCC, while they cannot singularly replace rapid evacuation, can help mitigate extended evacuation times for a trauma patient.

To save lives on the battlefield, it is critical for health teams to rapidly and proficiently enact the TCCC concepts within the first fifteen minutes of a combat casualty. However, depending on the nature and severity of an injury, TCCC alone is not enough to affect survivability outcomes—but these same types of injuries cannot sustain waiting for sixty minutes to reach definitive care either; resuscitative or damage control surgical intervention may be required sooner. The primary objective of a damage control surgical element is to conduct immediate lifesaving stabilization surgery of an emergency trauma casualty to facilitate safe movement of that casualty to a higher level of care. Under most circumstances, if patients are stable enough to go directly to the higher level of care, they will be transported, reserving the damage control surgical suite for those who genuinely do not have enough time to live to arrive at a higher level of care. These teams typically perform services such as airway restorations, hemorrhage control, and fracture stabilization to the thoracic, abdominal, and orthopedic regions.[29]

While the concept of forward-positioned surgical capabilities on the battlefield is not a new one, recently the U.S. military has experimented with new, smaller, lighter, and even more mobile configurations that require fewer personnel, less equipment, less infrastructure, and fewer resources to save lives in austere locations. With forward surgical team doctrine dating back to the early 1990s, the composition, operating guidelines, and capabilities are non-doctrinal and are primarily based on lessons learned from nearly two

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[28] Russ S. Kotwal et al., "Eliminating Preventable Death on the Battlefield," *Archives of Surgery* 146, no. 12 (December 2011): 146, https://doi.org/10.1001/archsurg.2011.213.

[29] U.S. Army, Field Manual FM 4-02.25 (FM 8-10-25) Employment of Forward Surgical Teams: Tactics, Techniques, and Procedures (Washington, D.C.: U.S. Army Government Printing Office, 2003), B1-B10.

decades of war, combined with improvements in life-saving techniques and knowledge, and finally medical technological advancements. All of these factors have reshaped what these teams are capable of and what they require to accomplish their mission.

Currently, all four branches of the U.S. military maintain an off-the-shelf resuscitative surgical team concept; however, recent conflicts have proven that these elements are often scalable or can be configured in an ad hoc fashion, both in equipment and personnel requirements. Though smaller and lighter configurations have more limited capabilities, they are also able to be tailored to fit the mission they are supporting. The Navy and Marine Corps currently maintain two similar configurations, the Forward Resuscitative Surgical Suite, and the Expeditionary Resuscitative Surgical Suite. According to the Department of the Navy, these elements are "designed to perform expeditionary resuscitative life- and limb-saving surgery on amphibious and other expeditionary platforms in support of tactical missions in the area of responsibility (AOR) which allows for providing critical surgical care within the golden hour or extending the golden hour requirement on mission planning."[30] The Air Force additionally has an off-the-shelf capability, the Special Operations Surgical Team, and the Army maintains a plethora of configurations in its forces that provide similar capabilities.

In 2009, Brian Eastridge et al. gathered data on surgeries performed by these types of elements, including basic demographics, mechanism of injury, injury severity score, and mortality outcomes. They determined that there was no significant difference in life-saving results to that of a Level III combat support hospital.[31] The scholars analyzed 2,617 injured-in-action servicemembers who were taken to a combat support hospital (CSH) or forward surgical team (FST) and were not able to make it back to combat in less than seventy-two hours. The study began during the earlier phases of the Iraqi war and did not

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[30] Paul J. Williams, "Navy Expeditionary Mobile Trauma Team Demonstrates Capabilities at IMCMEX," U.S. Naval Forces Central Command Public Affairs, April 18, 2016, accessed 4 September, 2017, http://www.navy.mil/submit/display.asp?story_id=94232.

[31] Brian J. Eastridge et al., "Forward Surgical Teams Provide Comparable Outcomes to Combat Support Hospitals During Support and Stabilization Operations on the Battlefield," *The Journal of Trauma, Injury, Infection, and Critical Care* 66, no. 4 (April 2009): 48–50, https://doi.org/10.1097/TA.0b013e31819ce315.

end till 2006. Their casualty records comprised 610 Marines, 18 airmen, 1,936 soldiers, and 53 sailors; of them, 77 had DOW upon arrival at a trauma facility while the other 2,540 survived. Fifteen of the casualties first received care in an FST, whereas sixty-two of them joined in a CSH. For the survivors, 649 and 1,891 started receiving treatment at an FST and a CSH, respectively. The researchers could not find statistical correlation in this data.

The results of this study are paramount, as they reinforce that these patients can, in fact, have the same survivability of their more robust parent levels of care. The implication is that trauma casualties who have access to a forward surgical element can, in fact, be well outside the sixty-minute window of evacuation to a Level III care facility without any degradation to their chance of survival from severe acute trauma.

E. POTENTIAL EXPLANATIONS AND HYPOTHESES

There is significant evidence to suggest that when the appropriate point of injury procedures are taken, the sixty-minute window of evacuation is not as necessary as we once thought it was, or at least it will certainly not be for future operations. Medical practitioners assert that the quicker a trauma casualty reaches definitive care, the more favorable the outcome. However, the data suggests that interventions applied within the more critical first ten to fifteen minutes are more imperative. It is also clear that, considering all variables, it is tough to conclusively say that reducing evacuation times has truly lowered mortality and morbidity rates among servicemembers. Moreover, the research affirms that there is little empirical data to support that sixty minutes or less is a unique window of opportunity when; in reality, the more important window for care is within ten to fifteen minutes. This is why ground medical personnel who are proficient in the guidelines of TCCC can significantly affect the survivability of U.S. servicemembers. When TCCC is not followed appropriately, there are preventable deaths. We also know that having resuscitative surgery capabilities when postured in close proximity to the most kinetic, or potentially kinetic areas, incredibly impacts the survivability rate for stabilization cases, and often buys time.

This thesis hypothesizes that U.S. military units with front-line warfighters who are proficient in TCCC and able to execute it properly within its guidelines, combined with

small resuscitative surgical capabilities located as far forward as their mission requirements allow them, can safely conduct military operations outside of the sixty-minute window of evacuation without a degradation to the best available combat health support or a reduction in trauma survivability.

F. RESEARCH DESIGN

This thesis uses existing research and data on survivability rates of trauma patients based on evacuation times to appropriate levels of definitive care. The thesis also uses existing data of similar trauma patients who received other forms of treatment at the point of injury but did not reach definitive care within sixty minutes. An essential aspect of this study is an analysis of whether the data supports that proper TCCC performed immediately following injury, and/or damage control resuscitative surgical intervention when appropriate in the early stages of trauma sustainment, can equal or improve the outcome achieved through evacuation within a sixty-minute window. Additionally, this thesis examines the financial, resource, and personnel expense of sustaining a sixty-minute evacuation standard vice the TCCC training and mobile/scalable resuscitative surgical teams to determine the practicality and life-saving capability of each. This could lead to policy recommendations that enable the most practical employment of capabilities aligned with the most effective combat health support to the fighting force.

G. THESIS OVERVIEW

The purpose of this thesis is to ultimately suggest that the sixty-minute standard of evacuation is no longer practical or applicable to future operations that will be required of the U.S. military, and that the same level of combat health support is made available to the fighting force through proficiency in Tactical Combat Casualty Care at the individual level and through the use of mobile resuscitative surgical elements.

The thesis began by briefly describing the origination of the golden hour concept and how it was implemented, followed by a discussion about the nature of injuries servicemembers were sustaining and their evolution through Operation Enduring Freedom. In later chapters, the thesis reviews the research to determine the outcomes of reduced evacuation times were and highlights the resource-intensive requirements, additional risks,

and drawbacks associated with maintaining this standard. This involves analyzing the current standard battlefield injury treatment objectives, requirements, and protocols, and how adhering to this standard is not practical for future operating environments.

The thesis then describes Tactical Combat Casualty Care, its current implementation, and how, when put into practice proficiently, it can affect the survivability of a trauma casualty. Additionally, the work identifies how resuscitative surgical teams positioned closer to the population at risk, combined with TCCC, proficiency can have the same effect as reduced evacuation time, but with much less cost and risk and in a more conducive manner to support future operations and operational environments.

Finally, the thesis concludes with a suitable modification of the sixty-minute standard of evacuation policy and makes recommendations based on a possible change to practice for most practical employment of capabilities that still provides the most effective combat health support to the fighting force.

III. METHODOLOGY

This chapter describes the selection criteria the author used during the research process and defines why the studies that did not make it into the systematic review were left out. Information was collected from a wide array of study designs, most of which included observational reports—such as comparative cohort and longitudinal group studies, as well as cross-sectional explorations. Most of the studies were conducted by members of the American military and medical practitioners, particularly surgeons and doctors who facilitate therapy interventions for combat-based trauma victims.

Following PRISMA-P standards,[32] for a study to qualify for review in this thesis, its authors must have clearly indicated when they conducted the research and have reported their data-gathering methodology and analysis techniques. All the subjects in the selected studies were servicemembers who were victims of trauma. Additionally, since the author of this thesis did not have access to translation services, studies must have been written in English. There were no restrictions on duration of research; some of the studies used for this thesis assess patient records over a period of just twelve months, while others gathered their data for more than a decade. The latter had a more profound impact and therefore warranted more attention.

The author worked closely with a research librarian to develop an efficient search strategy. The articles were retrieved from databases including Scopus, NCBI, EMBASE, Web of Science, JSTOR, ProQuest, and MEDLINE. Search terms included TCCC, the golden hour rule, and trauma victims, and the same search criteria were replicated across all the electronic databases. Each electronic database provided more than fifty resources, which the author kept track of using the software EndNote, which allowed him to identify duplicate studies. As an online platform, EndNote also performs data extraction and article-screening tasks. The papers must have received a noteworthy support quorum within the military and scientific communities to be considered high quality; accessibility via the

[32] PRISMA-P consists of a seventeen-item checklist intended to facilitate the preparation and reporting of a robust protocol for a systematic review to ensure accuracy and reliability of the information.

scientific journal databases alone was not enough to determine the value of a resource. More importantly, the author relied on the AMSTAR scale to validate the articles, particularly the quality of methodological approaches. The tool helped establish whether or not the study designs met the minimum scientific requirements for eligibility. Even though the brains behind AMSTAR acknowledge the need to expose their platform to additional testing, the tool already has a unique value proposition. It helped the author come up with pragmatic research questions and the data inclusion criteria even before the systematic review commenced. AMSTAR's emphasis on the utility of an independent reviewer minimized the risks of bias during the current study, and it provided an avenue for the author to develop an extensive literature review that paid attention to the most instrumental keywords.

A. THE SELECTION PROCEDURE

The article selection stage was conducted in two phases. In the first phase, the author screened the abstracts and titles of the papers from search results for eligibility criteria. In the second phase, the author thoroughly reviewed the eligible content to confirm that the study was relevant to the research's thematic concerns. To avoid biases, an independent party was present to confirm that the resources would be beneficial to this study. Another reviewer was invited to consult as needed, though most of the conflicts eventually resulted in a mutual understanding. The selection process was oblivious to authorship, institutions of origin, and the databases where the articles were found. However, all selected studies had to be peer-reviewed. Finally, although case a study made it to the screening stage, it was eventually excluded, as discussed in more detail later.

B. THE DATA COLLECTION PROCEDURE

The author mainly focused on four parts of the studies during the data collection process: research background, methods, results, and conclusions. This allowed the author to uncover the objectives of each study and the connection the scholars hoped to establish. Also important were the sample size and study design. To negotiate the vast information, the author worked alongside an independent reviewer who helped uncover inconsistencies.

The duo also compared notes to determine which findings were relevant to the current study.

A data extraction form also facilitated this process; borrowed from the *Cochrane Handbook for Systematic Reviews of Interventions*, the form ensured that all pertinent questions are addressed. Unlike other meta-analyses whose data collection methodologies allow the scholars to develop separate forms for every article, this study only incorporated a single report for each resource. However, every form was cross-checked, which reduced the risk of inaccuracies or inconsistencies. When a discrepancy was discovered, the error was double-checked by an independent reviewer who would also approve any necessary alterations. Any important missing data was gathered by reaching out directly to the researchers through social media and e-mail correspondence. However, the author only made one attempt to establish communication with these scholars due to limited time.

C. POSSIBILITIES OF BIAS

The author's use of an independent researcher reduced the risk of bias significantly, but the application of the NOS, or Newcastle-Ottawa Scale, mitigated bias further. This scale was tailored for nonrandomized explorations such as cohort research; it is also applicable for cross-sectional reports. NOS helped determine whether specific articles had high or low bias; some even received an "unclear" rating. Attributes that facilitated the grading process include sample size, confounding risks, and rates of attrition. While this thesis uses studies that have low bias, articles that rated high or unclear for bias also informed the author's judgments, though the bias was kept in mind when determining validity and accuracy.

D. SYNTHESIS OF DATA

The data extracted from the studies was presented in the literature review (Chapter II) and is also explored in the analysis (Chapter III). Most of the resources discussed the ability of the golden hour rule to improve the wellbeing of injured servicemembers, and whether TCCC was a better strategy than minimizing scene and transport times. The data synthesis procedures acknowledged the existence design, sampling, and procedural biases in some of the articles under scrutiny.

E. QUALITY ASSESSMENT

The study adopted the following assessment principles, which demonstrate the comparability and quality of the articles.

- Research scope: The thesis author must demonstrate that he explored ample databases with reliable search results and must disclose restrictions on the age of the eligible studies.

- Inclusion criteria and review selection: The scholars who published the original articles should include the details about their research identification as well as eligibility principles.

- Analysis of presentation bias: The scholars who published the original articles should have reached out to authors they cited for additional information. They must also have conducted statistical examinations, such as funnel plot analysis, to uncover any prejudice, and made the details available for the audience.

- Analysis of heterogeneity: The scholars who published the original articles should have included information about a heterogeneity test. If these authors determined the existence of notable heterogeneity, they should have used statistical assessments with the aim of resolving it.

- Relativity of provided reviews: The eligibility criteria, primary outcomes, and study designs of all reviews should be comparable. For example, as the author assessed the impact of TCCC on the quality of lives of injured servicemembers, he considered both favorable and unfavorable outcomes that resulted in fatalities.

IV. DATA ANALYSIS

A. THE EFFECTIVENESS OF REDUCED EVACUATION TIME

An examination of the impact of emergency medical services (EMS) on mortality rates among victims of trauma shows that shorter evacuation times improve patient outcomes.[33] One study, which involved a secondary assessment of all trauma patients admitted to hospitals between 1996 and 2009, included 19,167 victims of trauma.[34] Out of this aggregate, 4.5 percent died; 84 percent of the sample size suffered due to blunt injuries, 3.7 percent of whom succumbed to their wounds.[35] Having gathered this data, the researchers needed to determine the correlation between morbidity and scene as well as transport times. According to the study results, mortality rates were directly proportional to scene time. When the researchers controlled for sex, Revised Trauma Score, age, and Injury Severity Score, using regression analyses they discovered that scene durations exceeding twenty minutes resulted in additional deaths when compared to those that lasted no more than ten minutes.[36] However, the authors did not discover a robust positive correlation between the likelihood of death among patients with penetrating trauma and scene times between ten and nineteen minutes. Furthermore, the mortality of blunt trauma victims did not rise with transport or scene times. It can therefore be concluded that severe shock casualties require medical assistance within twenty minutes to increase their chances of survival.

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[33] Dan Bieler et al., "Does the Presence of an Emergency Physician Influence Pre-hospital Time, Pre-hospital Interventions and the Mortality of Severely Injured Patients? A Matched-Pair Analysis Based on the Trauma Registry of the German Trauma Society (TraumaRegister DGU®)," *Injury* 48, no. 1 (January 2017): 32–40, https://doi.org/10.1016/j.injury.2016.08.015.

[34] C. Eric McCoy et al., "Emergency Medical Services Out-of-Hospital Scene and Transport Times and Their Association with Mortality in Trauma Patients Presenting to an Urban Level I Trauma Center," *Annals of Emergency Medicine* 61, no. 2 (February 2013): 167–74, https://doi.org/10.1197/S1069-6563(03)00313-0.

[35] McCoy et al., 169-70.

[36] McCoy et al., 174.

Moreover, developments in trauma facilities are directly linked to a reduction in the amount of time it takes the patient to get to primary definitive care. Jana MacLeod and her team of researchers observed that a proportion of trauma victims with critical injuries who end up dying just after arriving at a health care center die due to curable causes.[37] The researchers examined deaths that occurred within the golden hour by assessing medical entries, autopsy reports, and trauma records of more than 550 casualties. They calculated the median prehospital time to be thirty-nine minutes; they also established that the Injury Severity Score had a median of twenty-nine.[38] Overall, blunt trauma, which accounted for more than 50 percent of all deaths, frequently occurred as a result of injuries stemming from motor vehicle accidents. On the other hand, about half of all the penetrating injuries resulted from gunshot lesions that affected the thoracic cavity. Victims suffering from critical injuries were more likely to complain about isolated head injuries involving the brain. Moreover, noncritical injuries would only concern a vessel or an organ, and they impacted approximately 38 percent of the cohort. Only 4 percent of them suffered from isolated spleen wounds, translating into 4 percent of the sample size. The scholars concluded that a notable proportion of the patients who had high chances of surviving the trauma only had one organ impacted during the attack, and this did not include brain injuries. Additionally, the researchers posit that there is a need for aggressive medical intervention strategies, particularly targeting victims who exhibit severe injuries during the prehospital time.[39]

To improve combat casualty care, "[a] thorough understanding of the epidemiology of death post battlefield injury is of vital importance."[40] In "Death on the Battlefield," Brian Eastridge et al. analyzed deaths that occurred after casualties reached a medical

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[37] Jana B.A. MacLeod et al., "Trauma Deaths in the First Hour: Are They All Unsalvageable Injuries?" *The American Journal of Surgery* 193, no. 2 (February 2007): 195–99, https://doi.org/10.1016/j.amjsurg.2006.09.010.

[38] MacLeod et al., 196.

[39] MacLeod et al., 196.

[40] Brian J. Eastridge et al., "Death on the Battlefield (2001–2011): Implications for the Future of Combat Casualty Care," *Journal of Trauma and Acute Care Surgery* 73, no. 6 (December 2012): S431–37, https://doi.org/10.1097/TA.0b013e3182755dcc.

treatment facility between October 2001 and June 2011; the goal was to create a comprehensive report and broaden perspectives. They evaluated postmortem records from the Office of the Armed Forces Medical Examiner (OAFME) for patients classified as DOW from combat injuries after arrival at definitive care.[41] The injuries were classified by a panel of military trauma experts, consulting with an OAFME forensic pathologist, as either nonsurvivable or potentially survivable. Data from the Joint Theater Trauma Registry and the OAFME Mortality Trauma registry were also obtained, and included demographics, mechanism of injury, laboratory information, and physiologic variables, as well as the cause of death. DOW casualties after reaching definitive care (n=580) constituted 12.7 percent of total, combat-related injuries during the study period. Of the cases, 46.8 percent (271) were classified as nonsurvivable while 49.5 percent (287) were deemed potentially survivable.[42] The predominant battlefield injury leading to death was traumatic brain injury, causing 83 percent (225) of the nonsurvivable cases, whereas the foremost mechanism of death was hemorrhage from major trauma, causing fatality in 230 of 287 (80 percent) of the potentially survivable situations.[43] The major body regions where bleeding occurred in hemorrhages for potentially survivable cases were the torso (48 percent), extremity (31 percent), and junctional—neck, groin and axilla (21 percent). Over half of DOW casualties presented in extremis.[44] There was an attempt at intervention with cardiopulmonary resuscitation upon presentation. This study shows a marked need for initiatives to mitigate bleeding in prehospital environments, as hemorrhage was the most predominant mechanism of death in potentially survivable combat injuries.[45]

In "Relative Mortality Analysis of the 'Golden Hour,'" Phillip Schroeder et al. sought to determine if existing literature contained objective truths about golden hour statistics by uncovering inherent limitations. The scholars doubled down on the role that

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[41] Eastridge et al., 432.

[42] Eastridge et al., 432-33.

[43] Eastridge et al., 433-34.

[44] Eastridge et al., 433-34.

[45] Eastridge et al., 434, 435-36.

prehospital time plays in reducing mortality rates among trauma patients. Since papers that oppose the golden hour policy also fail to accurately factor inpatient acuity's confounding impacts on the connection between deaths within trauma populations and prehospital time, the authors used the Relative Mortality Analysis based on a new acuity stratification design.[46] The approach considered the victim's chances of survival and employed the Trauma and Injury Severity Score to calculate an all-inclusive triage metric. Overall, this methodology exposed significant loopholes in studies that oppose the golden hour rule. The failure of some study findings to support the golden hour policy could have stemmed from the use of flawed methodologies, not necessarily from the ineffectiveness of the sixty-minute rule.[47] In contrast, Relative Mortality Analyses registered accurate results regardless of context. Case in point, when the researchers used this framework to probe the same population that other studies posited could not benefit from a quick response, it led to the observation of a new subgroup. About 10 percent of the patients who had a potential-of-survival rate between 23 and 91 percent experienced a significant reduction in mortality if they were transported to a health care center in less than an hour.[48] Thus, the study notably supports the efficacy of the golden hour rule in minimizing morbidity among victims of war.

A team of surgeons set out to assess if the availability of helicopter emergency medical services (HEMS) reduced deaths among trauma patients and if prehospital periods impacted mortality. They analyzed data gathered from a Level I trauma facility covering the period from 2003 to 2008.[49] All the patients under analysis had experienced trauma and received both EMS and HEMS. Another control group of 186 subjects formed part of the study, with the methodologies ranging from Revised Trauma Scores to the calculation

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[46] Phillip H. Schroeder et al., "Relative Mortality Analysis of the 'Golden Hour': A Comprehensive Acuity Stratification Approach to Address Disagreement in Current Literature," *Prehospital Emergency Care* 23, no. 2 (August 2018): 254–62, https://doi.org/10.1080/10903127.2018.1489021.

[47] Schroeder et al.

[48] Schroeder et al., 260.

[49] Mariska A.C. de Jongh et al., "The Effect of Helicopter Emergency Medical Services on Trauma Patient Mortality in the Netherlands," *Injury* 43, no. 9 (September 2012): 1362–367, https://doi.org/10.1016/j.injury.2012.01.009.

of odds ratio, as well as the numbers needed to treat (NNT). Finally, they used logistic regression to examine the impact of scene time deaths. Their findings echo the value of HEMS in reducing fatalities among patients with traumatic brain injuries (TBIs). The odds ratio remained constant among both TBI and non-TBI patients. In comparison, with an NNT of -15 and an odds ratio of .3, EMS- and HEMS-assisted patients were (nonsignificantly) less likely to die in the hospital than those who only received EMS services. When the researchers adjusted their data for scene times, they observed that fatality reduced among TBI victims who had access to HEMS (from an odds ratio of 1.3 to 0.8). As a result, the study concluded that TBI and non-TBI victims are less likely to succumb to their injuries in the presence of HEMS therapy, though the impact is not statistically significant. The higher the scene time, the more likely it is that TBI sufferers will die in battle.[50]

Another team of researchers, Craig Newgard et al., discovered a correlation between the golden hour rule and a reduction in fatalities among trauma patients who needed access to critical resources. The group focused on TBI and shock victims to illuminate a link between scene time and patient outcomes. Study respondents were at least fifteen years old, had visited the health care facility being studied between 2006 and 2009, their aortic blood pressure did not exceed 70 mmHg, and their pulse was 108 beats/min or above. Out of the 778 and 1,239 sample sizes for the trauma and TBI cohorts, respectively, 26 percent of the former dichotomy experienced twenty-eight-day morbidity, whereas the latter had a 53 percent mortality rate when observed over a half-year period.[51] In general, scene times lasting longer than sixty minutes did not impact fatality among the shock group, though, with an adjusted odds ratio of 1.42, the TBI patients were more likely to succumb to their injuries if they failed to make it to the hospital within the hour.[52]

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[50] de Jongh et al., 1362.

[51] Craig D. Newgard et al., "Revisiting the "Golden Hour": An Evaluation of Out-of-Hospital Time in Shock and Traumatic Brain Injury," *Annals of Emergency Medicine* 66, no. 1 (July 2015): 30–41, https://doi.org/10.1016/j.annemergmed.2014.12.004.

[52] Newgard et al., 30.

Moreover, these scholars—who wanted to establish the impact of evacuation time on patient outcomes—concluded that as long as the trauma victims received adequate medical care on the battlefield, there was no correlation between wellbeing and prehospital periods. However, because they failed to juxtapose the impact of poor-quality health care with longer scene durations, they lacked an appropriate control group for the study. And since the study focused on rural areas, the researchers assumed that the rate of deaths that resulted from preventable causes was 13 percent. Relative to similar studies, this is significantly low. In their conclusion, the authors observed that focus should shift away from reducing prehospital time and should instead be directed toward the quality of care that servicemembers receive on their way to the nearest trauma facility. According to the researchers, victims of nonsurvivable injuries will eventually succumb to their wounds, but the survival rates of servicemembers with other injuries are tied to how soon they undergo procedures like hemorrhage and airway control or fluid resuscitation. Overall, they did not refute the assumption that longer scene times increase mortality rates.[53]

Another research team, headed by John Clarke, concluded that evacuation times indeed have potential advantages to servicemembers, particularly when they do not exceed four hours.[54] However, the study excluded female trauma victims and victims younger than forty-eight, which makes the findings invalid.

Clarke and his colleagues set out to compare the quality of the primary care provided by Level I shock facilities with the care offered at facilities of a lower rating.[55] According to their findings, evacuation times play a noteworthy role in reducing mortality rates when victims receive prompt initial care, contrary to the prevailing assumption that reducing prehospital time is the superior strategy. As long as the patient's access to advanced resuscitative procedures remains unconstrained, their chances of survival escalate. Since the scholars did not assess the influence of the period between wound

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[53] Newgard et al., 41.

[54] John R. Clarke et al., "Time to Laparotomy for Intra-abdominal Bleeding from Trauma Does Affect Survival for Delays up to 90 Minutes," *Journal of Trauma and Acute Care Surgery* 52, no. 3 (March 2002): 420–25, https://doi.org/10.1097/00005373-200203000-00002.

[55] Clarke et al., 423-24.

infliction and initial revival, their research cannot invalidate the golden hour rule in combat. They should also have determined the superiority of the primary care that the trauma patients received both during scene time and upon arrival at the hospital.

When Michael Dinh et al. examined the importance of the golden hour rule for victims with blunt head trauma, they observed that lower transportation times were crucial. The researchers relied on a retrospective group of victims who had critical head trauma between 2000 and 2011 and managed to arrive at the emergency department in less than one day.[56] They used several techniques to gauge the impact of prehospital time on the average morbidity rate, and concluded that the longer the patients took to arrive at the hospital, the more likely they were to succumb to their injuries. However, there was no correlation between prehospital times of one hour or longer and the chance of survival. That is, mortality rates were not connected to the golden hour rule.[57] That said, patients who arrived at care facilities about two hours after their injury benefited from prompt transportation periods. While the golden hour policy did not influence survivability, patients whose evacuation periods occurred within one hour were more likely to be discharged from the trauma facilities without the need for continuous rehabilitation.

B. RISKS AND DRAWBACKS TO U.S. POLICY

For a variety of reasons, a growing number of military scientists are skeptical of the golden hour rule. For starters, early debates about the effect of reducing prehospital times on the quality of the servicemembers' lives mainly doubled down on advancing medical services to the cohort, primarily the trauma victims. What is worse, the discussions paid no significant attention to empirical data; some of the medical practitioners were not required to back their assertions with concrete evidence. Yet most of the information was taken to be factual, particularly when it came from industry leaders like Dr. Cowley. During that period, the mainstream trauma facilities in the United States were not as advanced as

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[56] Michael M. Dinh et al., "Redefining the Golden Hour for Severe Head Injury in an Urban Setting: The Effect of Prehospital Arrival Times on Patient Outcomes," *Injury* 44, no. 5 (May 2013): 606–10, https://doi.org/10.1016/j.injury.2012.01.011.

[57] Dinh et al., 610.

they are in contemporary America, and there was no reliable record-keeping system to provide supporting evidence of medical standards and practices.

Moreover, even though the golden hour standard originated in military medical practices, and its major objective is to offer a better quality of trauma care, the policy is irrelevant in the contemporary world of health care. Case in point, former proponents of the golden hour rule, like W. Kendall McNabney, contributed scientifically invalid studies to discredit opposing views.[58] When assessing the impact of prehospital time on mortality rates, McNabney's major flaw was considering only the servicemembers who did not die on their way to the trauma centers. As a result, his statistical analyses failed to account for important data, such as the scene time mortality rates.

It is also risky to use the golden hour as an effective rule of thumb since critical windows tend to vary depending on the type or severity of trauma. Additionally, the part of the body that has been injured plays a critical role in determining servicemembers' chances of survival, whether or not their prehospital times last less than an hour.

Critics of the golden hour further posit that the policy might be beneficial for civilian populations that experience little or no threat of war, but the military, which has fewer resources during combat, has heightened risks of attacks and insecure evacuation routes. Unlike in the military, civilians have the advantage of maximizing their EMS based on anticipated demand (generally guided by population growth patterns). For instance, a metropolitan city could construct additional trauma facilities to support regions with the highest population densities to provide adequate coverage for all its residents. In the military, however, servicemembers tend to lack the luxury of time for planning and construction, or are unable to sustain a permanent link of health care centers in the long run. During combat, the military constantly faces the challenge of having to quickly situate, identify, and transport trauma victims to the nearest or safest facilities—Herculean tasks if the victims are in war-torn areas.

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[58] W. Kendall McNabney, "Vietnam in Context," *Annals of Emergency Medicine* 10, no. 12 (December 1981): 659–61, https://doi.org/10.1016/S0196-0644(81)80094-7.

Considering the aforementioned conditions during battle, observing the golden hour rule would require vast financial and labor resources. Although it is true that the one-hour rule has the capacity to save numerous lives, as witnessed during the Vietnam War, for example, the success of this policy was tied to a plethora of other factors. Advancements in medicine during the 1950s allowed medical practitioners to transfuse blood that contained clotting components and red blood cells, an innovation that was not commonplace during the Vietnam War. Another prerequisite for a practical establishment of the one-hour rule is the availability of efficient, talented, and organized medical groups that can offer quality health care to trauma victims within well-equipped temporary structures. The U.S. military also had to invest significantly in the training and employment of both medical and surgical specialists, and leverage advancements in medical logistics to effectively plan for and control the necessary medical supplies.[59] Considering the investment requirements and the more than 97 percent survival proportion (which never factored in the deaths that occurred during scene time), the golden hour rule is not such a practical idea after all.

For example, McNabney describes a study conducted to challenge existing assumptions about the golden hour; the main objective was to gather empirical data from past literature regarding the role that scene times play in improving patient outcomes. The researchers used systematic reviews to determine this correlation, and the meta-analysis involved the collection of data since the founding of the databases the scholars used (Cochrane Library, MEDLINE, and Embase) until 2014. Most of the literature under review included studies about EMS and scene time periods, prospective trauma confounders, and outcome parameters.[60] The researchers uncovered evidence in favor of and against the golden hour rule. In their analysis of at least twenty studies, the authors observed that trauma victims were less likely to succumb to their injuries when the prehospital times were brief. In contrast, the same cohort was more likely to survive when the aggregate scene time increased. That is, trauma patients were less likely to survive

[59] McNabney., 661.

[60] McNabney., 661.

when they were exposed to prompt transportation, especially among those with TBIs. Therefore, swift transport services should be offered selectively to victims of injuries like neurotrauma, whose conditions are not likely to worsen. However, stable trauma sufferers do not stand to significantly benefit from shorter prehospital intervals, and medical practitioners should instead concentrate on providing exceptional care on their way to the hospital.

According to John Holcomb et al., the success of battle shock management therapies depends on comprehensive awareness about the epidemiology of combat-related mortalities. As part of their methodology, they assessed autopsy records, treatment data, and photos of servicemembers who succumbed to injuries inflicted during special operations. The authors collected data from eighty-two casualties of war from 2001 to 2004; they dichotomized serious injuries as either potentially survivable or nonsurvivable.[61] They also made observations about the medical equipment and the level of training of the health care workers accessible to the patients. Finally, they performed structured assessments to determine what training and equipment were necessary for a more favorable outcome in the future. The researchers discovered that 6 percent of the fatalities, whose bodies also went missing, were due to injuries sustained from aircraft accidents. Exactly nineteen deaths stemmed from nonbattle wounds, while the other sixty-three were war-related. Of the cohort, 43 percent died due to explosions, whereas gunshot injuries and blunt trauma were responsible for 28 percent and 6 percent, respectively.[62] Out of the eighty-two mortalities, 70 percent were considered nonsurvivable. The leading causes of death for the survivable wounds included comprehensible hemorrhage (19 percent), truncal hemorrhage (50 percent), and tension pneumothorax (6 percent). They concluded that most of the deaths associated with combat in this age were not survivable.[63] To improve patient outcomes, the authors urged the military to advance procedures like

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[61] John B. Holcomb et al., "Causes of Death in U.S. Special Operations Forces in the Global War on Terrorism: 2001–2004," *Annals of Surgery* 245, no. 6 (June 2007): 986–91, https://doi.org/10.1097/01.sla.0000259433.03754.98.

[62] Holcomb et al., 987-89.

[63] Holcomb et al., 991.

non-compressible hemostasis, intracavitary or intravenous, and minimize evacuation times for patients who require surgery.

There are no demonstrable examples of tri-modal death distribution within the modern military conflict. Recent data from Palestine, Israel, and the United Kingdom reveal that nine of every ten soldiers injured during battle die within minutes of being wounded from unsalvageable trauma, and that having a surgeon on the battlefield makes no difference to their survival rates. When there is definitive airway control using rapid-sequence induction and intubation, there are marked benefits to the injured head and airway. Once securing the airway, a soldier can receive intensive care during transportation for approximately two hours. Intensive care treatment that can be administered during transport includes hypotensive resuscitation, blood transfusion, adjunctive clotting factors, antibiotics, analgesics, novel hemostatics, splintage, and FAST scanning.[64]

Truncal bleeding and central nervous system injury cause the second peak of death. Soldiers with truncal or junctional bleeding need a large amount of surgical, logistic, and hemostatic intervention.[65] Those with nervous system injuries need a CT scan and specialized neurosurgical treatment, and do best in hospitals with adequate resources. Any stops en route to well-resourced, larger hospitals have not proven to be of any benefit; it is the opinion of many experts that resources must be geared toward saving the many that can be saved rather than optimized for the few who cannot be.[66] Wounded soldiers receive the best outcomes when they undergo surgery in operating theaters of large hospitals within three hours of injury.

American military policies have put significant emphasis on the importance of prompt evacuation of injured servicemembers, but they do not have an absolute definition of how quick the process should be. Military leaders like Gates have echoed the

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[64] A.M. Harmsen et al., "The Influence of Prehospital Time on Trauma Patient's Outcome: A Systematic Review," *Injury* 46, no. 4 (April 2015): 602–09, https://doi.org/10.1016/j.injury.2015.01.008.

[65] Paul J. Parker, "Casualty Evacuation Timelines: An Evidence-Based Review," *Journal of the Royal Army Medical Corps* 153, no. 4 (2007): 274–77, https://doi.org/10.1136/jramc-153-04-11.

[66] Parker, 274-77.

timelessness of evacuation procedures, and no policy document talks about the need for prehospital times that do not go beyond the first hour of wound infliction. The operational influence of Level III trauma centers is not influenced by any doctrine, but the golden hour rule is fortified in the Mission Command Training Program at Fort Leavenworth, professional military systems of education, and the U.S. Army Combined Arms Center. Nevertheless, Army regulations dictate that critical surgical trauma victims must receive prompt medical assistance, no less than an hour after injury. The standard takes into account variables like distance and time and encourages rescue missions to consistently provide quality care as the victims make their way to the nearest trauma facility. Army doctrines acknowledge the value of lifesaving and immediate medical assistance and have set rules and structures that support the evacuation of injured soldiers within sixty minutes.[67] In fact, soldiers are trained to complete most of their operations in less than an hour, though the department still needs to get rid of the equivocal rubrics governing medical evacuation.

To receive formal approval from the American College of Surgeons, trauma facilities have to avail of a shock specialist whenever resuscitations are conducted. The standard still exists even though researchers are yet to confirm its positive impacts on patient outcomes, particularly within cohorts that are not seriously injured. Due to this gap in research, A.M. Harmsen et al. wanted to determine the potential advantages of increasing scene times involving trauma surgeons on the wellbeing of Level II shock victims. Since 2011, the American College of Surgeons has insisted that the aforementioned cohort of patients should not have to wait longer than two hours, with the preferred time being less than an hour, before receiving the services of a surgeon.[68] Therefore, the authors wanted to observe if there was a connection between patient outcomes and the recommended response periods. They gathered retrospective data (2008 to 2011) for their control group, as well as prospective data (2011 to 2014) for the test group.[69] The researchers' primary

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[67] Harmsen et al., "The Influence of Prehospital Time," 603.

[68] Harmsen et al., 603.

[69] Harmsen et al., 605-06.

outcomes dealt with the duration of stay at the hospital and mortality, whereas the secondary outcomes discussed the period between the initial admittance to the emergency room until the performance of a CT scan.

C. THE EFFECTIVENESS OF TCCC

Since the 1990s, Tactical Combat Casualty Care (TCCC) has governed how victims of war receive emergency medical services, thereby influencing mortality rates stemming from preventable injuries or trauma. Some of the potential triggers of death covered by TCCC include airway obstruction and hemorrhaging. The United States officially incorporated TCCC into its military operations in 2005, followed by use for civilian populations as well as other nations allied to the United States. Analysis from the National Association of Emergency Medical Technicians shows that about 90 percent of deaths that result from combat occur outside trauma centers, or during the prehospital time.[70] Considering how strong the correlation is, first responders play a critical role in improving the quality of life and lifespan of casualties of war. However, it is expensive and time-intensive to train medical practitioners like surgeons to act as first responders in combat. When a significant proportion of the military budget is diverted toward medical care, though essential and life-saving, other items, like weaponry, suffer.[71] The introduction of TCCC has helped minimize the demand for medical staff, providing a less expensive alternative: nonmedical workers whose training and salaries are relatively less than what doctors demand.

TCCC trainees are able to handle a vast array of health emergencies, such as gunshot injuries and sheer amputations. Having gathered sufficient military know-how prior to their TCCC training, the beneficiaries of these programs are more susceptible to planning, deploying, and supervising practical battle-focused TCCC concepts. The trainees are also informed about the role they need to play in improving the quality of lives of their colleagues during prehospital periods, as well as the importance of organization training

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[70] Felix Figueroa, "Saving Lives through Tactical Combat Care," U.S. Army, July 12, 2018, https://www.army.mil/article/208440/saving_lives_through_tactical_combat_casualty_care.

[71] Figueroa.

sessions for regional servicemembers.[72] When soldiers can attend to hemorrhaging, protect or clear airways, apply tourniquets, and provide in-combat protection, more lives are saved, and so are taxpayer resources. More importantly, most recent studies confirm that TCCC not only mitigates the loss of lives in combat but also advances the organization of tactical missions that involve casualties. When Holcomb and his team of researchers assessed the details surrounding the deaths of more than twelve soldiers, they observed that eight of them would never have succumbed to their injuries if a TCCC trainee had been present.[73] Thus, a more widespread utility of TCCC principles could reduce the 90 percent mortality rate that is linked to fallen soldiers who never make it to the hospital.

Furthermore, TCCC has improved the quality of medical interventions that soldiers have access to during combat by fortifying the utility of tourniquets, which the Army now requires troops to carry. Tourniquets have been exceedingly effective at dealing with casualties that involve isolated extremity trauma, with few complications. One study reported that 57 percent of deaths occurring at the 31st Combat Support Hospital in Baghdad were a result of exsanguination and could have been averted by the appropriate application of a tourniquet.[74] Tourniquets are not prominently used in the civilian trauma care model, but the data revealing their effectiveness and potential to prevent death from blood loss by military units under combat conditions has prompted a call by several authors to expand tourniquet use to the civilian prehospital environment.[75]

When Beekley and his colleagues set out to conduct a meta-analysis of literature that conveyed information about noteworthy surgical lessons obtained from battle, about 50 percent of the developments the researchers observed were directly linked to TCCC

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[72] Figueroa.

[73] Holcomb et al., "Causes of Death in U.S. Special Operations Forces," 607.

[74] Frank K. Butler, "Two Decades of Saving Lives on the Battlefield: Tactical Combat Casualty Care Turns 20," *Journal of Special Operations Medicine* 17, no. 2 (2017): 166–72, https://www.jsomonline.org/Subscriber/articles/1702/20172166Butler.pdf.

[75] Butler, 166-72.

concepts.[76] For example, according to Robert Mabry and John McManus, TCCC has played a revolutionary role in improving how the military takes care of war victims during prehospital periods.[77] Moreover, Dr. Jeffrey Salomone, the chairman of the Prehospital Trauma Department of the American College of Surgeons Committee on Trauma, penned a letter to voice his support for TCCC strategies. He referred to the influence of TCCC on the American military's handling of shock therapy as a "dramatic advancement."[78] Salomone also commended TCCC for saving infinite lives in battle, for its ability to determine the significant reasons behind combat morbidity, and for how its procedures—like needle decompression and tourniquets—have been reinforced as notable therapy options.[79]

Finally, reports from combatant units across all forces with real-world experience implementing TCCC practices and equipment in combat scenarios have reported an overwhelming success in preventable death and loss of limb. Multiple SOCOM SoF units, US Army 3rd Infantry division, Madigan Army Medical Center, The 75th Ranger Regiment, USMC special operations, The Army Surgeon General's Task Force on Dismounted Complex Blast Injury, and the Defense Health Board all have voiced both their praise for TCCC, while also calling for its institution as mandatory training for all servicemembers.[80] Specifically, the 75th Ranger Regiment which is infamous for being an early adopter of ranger proficiency in TCCC reported the "incidence of preventable deaths

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[76] Alec C. Beekley et al., "Prehospital Tourniquet Use in Operation Iraqi Freedom: Effect on Hemorrhage Control and Outcomes," *The Journal of Trauma* 64, no. 2 (February 2008): 28–37, https://journals.lww.com/jtrauma/Abstract/2008/02001/Prehospital_Tourniquet_Use_in_Operation_Iraqi.7.aspx.

[77] Robert Mabry and John G. McManus, "Prehospital Advances in the Management of Severe Penetrating Trauma," *Critical Care Medicine* 36, no. 7 (July 2008): S258–66, https://doi.org/10.1097/CCM.0b013e31817da674.

[78] Frank K. Butler, "Committee on Tactical Combat Casualty Care Meeting Minutes, 22-24 July 2008," *Journal of Special Operations Medicine* (July 2008), https://www.jsomonline.org/TCCC/03%20CoTCCC%20Meeting%20Minutes/CoTCCC%20Meeting%20Minutes%200807.pdf.

[79] Butler.

[80] Frank K. Butler and Lorne H. Blackbourne, "Battlefield Trauma Care Then and Now: A Decade of Tactical Combat Casualty Care," *The Journal of Trauma Acute Care Surgery* 73, no. 6 (suppl 5) (December 2012): S395-402, https://doi.org/10.1097/ta.0b013e3182754850.

from failure to perform required interventions in the prehospital phase of care was zero. This lowest incidence of preventable deaths ever reported from a major conflict."[81]

In summary, since military scholars first codified the concepts of TCCC more than two decades ago, thanks to data gathered from corpsmen, pararescue teams, and other medical personnel, it has become the foundation of scene time trauma therapy. From the incessant utility of hemostatic dressings to tourniquets that have alleviated deaths linked to external hemorrhage, TCCC is overly valuable to the military. As the military continues to train all its staff and align its operational standards with TCCC practices, both America and its allies have improved their quality of scene time trauma care. Moreover, TCCC led to the establishment of notable organizations like the National Association of Emergency Medical Technicians and the White House's Stop the Bleed campaign—just two examples of the military's attempt to extend its effective medical services and policies to the civilian populations.[82] The move has advanced prehospital care and changed how the public responds to emergencies such as terror attacks and road accidents.

D. EFFECTIVENESS OF SURGICAL INTERVENTION CLOSE TO THE POINT OF INJURY

To assess the effectiveness of surgical intervention close to the point of injury, Clarke et al. probed the link between survivability and the time the surgeons took to conduct laparotomy. The researchers focused on victims suffering abdominal injuries and experiencing hypotensive bleeding as a corollary. Data collection exercises targeted trauma sufferers who visited the Pennsylvania Trauma Systems Foundation and had a solid organ, as well as isolated abdominal vascular injuries. The estimation of mortality rates was based on systolic blood pressure, scene time, and how long the patients spent in the emergency department prior to the laparotomy or succumbing to their injuries.[83] Overall, the authors worked with a sample size of 243 patients whose blood pressure registered between 30 and

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[81] Butler, 399.

[82] Butler, "Two Decades of Saving Lives," 172.

[83] Clarke et al., "Time to Laparotomy for Intra-abdominal Bleeding," 420-21.

90 mm Hg. The prehospital time was no more than three hours and no less than seven minutes, whereas the time taken inside the emergency department had an upper limit of 915 minutes. According to their findings, 40 percent of the patients passed on, accompanied by a surge in the blood pressure risk ratio and a decrease in systolic blood pressure. Another increase in the risk ratio was observed concerning the period between the time the patient entered the emergency department and when the laparotomy procedure commenced, up to the ninetieth minute, after which there was a significant reduction. Based on the logistic regression that the researchers performed, 165 trauma victims who spent a maximum of 1.5 hours inside the emergency department were more likely to die the longer they stayed in the emergency department. The rate of this increase in chances of death was 0.35 percent per minute.[84] The scholars established that the patients were more likely to survive when they spent less time waiting for the laparotomy procedure. Another factor that predicted morbidity rates was the severity of the hypotension. Therefore, the availability of a surgeon close to the point of injury has a direct impact on patient outcomes.

To address the assumption that scene time therapy involving complex, invasive procedures can reduce combat-related fatalities, the researchers wanted to observe how air ambulance groups exploit this logic in the contemporary world, and to determine the expertise and demand for such units among populations within the United Kingdom. To do so, they relied on records collected over about six years, focusing on cardiac arrest, injury mechanism, and death or procedural malfunction. In their analysis, they assessed 235 medical operations, 111 of which involved breathing, 108 regarding circulation, while 16 were for airway injuries. About 33 percent of the cardiac arrest victims achieved spontaneous circulation as the performance of invasive procedures more than quadrupled between 2003 and 2009.[85] The rise partly stemmed from the higher utility of intra-osseous and thoracostomy. Also, the rate at which the procedures failed surged during the use of needles for both cricothyroidotomy and chest decompression. The researchers concluded that procedural utility rose during the observation period, which was also marked by higher

[84] Clarke et al., 420-24.

[85] Clarke et al., 421-22.

mortality rates among patients who underwent slightly uninstructive operations for breathing and airway support. Fortuitously, chest decompression or surgical airway procedures did not cause any casualties. Therefore, the availability of more surgeons and other prehospital doctors has the potential to decrease mortality rates during initial treatment at the point of injury.

According to the meta-analysis of existing scholarly resources that probe the efficacy of the golden hour policy in the military, there is no absolute or definitive response to this conundrum. For example, whether or not one's chances of survival drop to zero after the initial hour post-injury depends on the specific type of trauma, among other significant factors. Blunt force shock and closed head wounds could result in death if the patient does not access a quality health care facility, but no tangible empirical evidence exists to validate the specific golden hour assertion.

Jason Nam et al. provide a fantastic description of how scalable surgical elements providing direct support helped extend the golden hour requirement to special operations forces in central Afghanistan during the 2019 summer fighting season. Their study was informed by the fact that hemorrhage is a common cause of death during war. Although the application of damage control resuscitation (DCR) helps reduce coagulopathy, oxygen debt, and hypoxia in trauma patients by prolonging the amount of time needed until the patient can reach damage control surgery (DCS), DCR in and of itself cannot extend the sixty-minute golden hour ring. The golden hour remains the acceptable time within which the patient must reach definitive hemostasis or a surgeon.[86] However, the limited availability of surgical and medical evacuation (MEDEVAC) teams across the theater compromises the attainment of the golden hour partly because of the large number of operations being carried out in remote areas. The use of surgeons who are capable of carrying out advanced procedures forward is considered by the United States military as a strategy that can address both DCR and DCS. The strategy has been applied since the 2003 Iraq campaign, when the concept of the forward surgical team (FST) was first employed.

[86] Jason J. Nam et al., "A SORT Plus a GHOST Equals: Experience of Two Forward Medical Teams Supporting Special Operations in Afghanistan 2019," *Journal of Special Operations Medicine* 19, no. 3 (2019): 117–21, https://www.ncbi.nlm.nih.gov/pubmed/31539446.

This involves shifting surgical teams from combat support hospitals to mobile units made up of smaller teams.

The Golden Hour Offset Surgical Treatment Team (GHOST-T) was borne from the traditional conventional forces FST. The idea behind the GHOST-T involves drawing between five and seven personnel organic to an FST to provide support to special operations forces (SOF) missions. The movements of the GHOST-T often include a colocation of a MEDEVAC helicopter and crew to ensure flight time constraints of the golden hour are met. While a traditional FST is composed of approximately twenty people, the challenges of extended flight times and unforgiving terrain campaigns in Iraq and Afghanistan necessitate FSTs to conduct split operations and reconfigure into more mobile ten-man teams. The split option (now referred to as an FSRT) provided the same capability as its big brother, but at a reduced capacity. The GHOST-T builds on the same idea by operating with a relatively smaller footprint and remaining more mobile.[87] The 8485th FST comprised two configurations of the GHOST-T: light and heavy. A light team is made up of five individuals—a surgeon, anesthetist, medic, surgical technician, and nurse; a heavy team comprises of seven individuals—a nurse, medic, surgical technician, two anesthetists, and two surgeons. Each configuration moves with a maximum of ten units of whole blood, fifteen units of liquid plasma, and fifteen units of packed red blood cells. GHOST-Ts differ from FSTs in the sense that, because they are committed to surgery, they do not hold any patients and include a limited number of personnel for the resuscitation of additional patients.

The Special Operations Resuscitation Team (SORT) includes an emergency medicine or internal medicine physician, three special operations combat medic (SOCM) advanced paramedics, and a critical nurse.[88] Other personnel in this team include a patient administrative specialist, a laboratory technician, and an X-ray technician. The special operations element commander may push this team forward to extend the golden hour.

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87 Nam et al., 119.

88 Tom Deal, "Special Operations Forces," U.S. Special Operations Command, March 2011, https://health.mil/Reference-Center/Presentations/2011/03/08/Special-Operations-Command.

SORT differs from both GHOST-T and FST in the sense that members of the team are given extensive tactical training to allow them to integrate with SOF teams, which gives them the ability to function under a wide range of tactical situations while avoiding cases where they become a liability for the commander.[89] The team treats patients on a wide range of casualty evacuation and other nonstandard platforms. The amount of whole blood, packed red blood cells, and liquid plasma carried by the SORT is similar to that carried by GHOST-T.[90]

Nam et al.'s study focuses specially on the 2019 summer fighting season, when SOF enhanced its commitment to counterterror operations in even more austere and distant areas. Most of these operations could not meet the golden hour standard because they were so far outside of MEDEVAC range, and due to extreme geography and weather that often limited air accessibility. This necessitated a work-around to enable the provision of DCS capabilities within one hour and allow for the extension of care not only before but also after the DCS, when necessary. This involved assigning a light GHOST-T to a SOF advanced operations base from the 848th FST. This was after the anticipation that immediate evacuation would not be possible in some cases while taking into account the high risk of more casualties.[91] The advanced operations base helped establish a mission support site for the assignment of SORT and GHOST-T. This helped to house one Operation Detachment Alpha (ODA), partner forces, a communications and security element, co-located MEDEVAC, and a valuable refueling and forward arming. The establishment of the ring allowed teams to stage combat operations out of the site and to conduct other combat operations in the area at night.[92] Both the SORT and GHOST-T helped expand the medical evacuation golden hour by up to forty nautical miles and prevented the fall of key district centers to the hands of the enemy.

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89 Nam et al., "A SORT Plus a GHOST Equals," 118.

90 Nam et al., 117.

91 Nam et al., 118.

92 Nam et al., 118.

Over the four-week study period, five patients were treated by the team on three different occasions, which helped in the determination of the strength of the combination of the GHOST-T and the SORT. The first patient treated was a partner force soldier who was evacuated from combat operations due to a gunshot wound. The patient required tube thoracostomy as well as needle decompression of the chest.[93] He was first taken to a host nation hospital for a chest tube and large hemothorax. The SORT and GHOST-T carried out several interventions, such as assessment of trauma, replacement of chest tube, replacement of central line whole blood resuscitation, and an extended examination utilizing Focused Assessment with Sonography for Trauma (FAST). A thoracotomy was conducted as he continued to decompensate. The second patient also had a gunshot wound to the torso. He was initially moved to a partner force hospital from for an exploratory laparotomy. On arrival, the patient was confused and hypotensive. Among the interventions carried out by the SORT and GHOST-T teams were assessment of trauma, placement of subclavian central line, thoracostomy tube placement, extended FAST examination, resection of the colon and small bowel, whole blood transfusion, and dressings. The patient was then transferred to a Level III facility for a definitive surgery due to an open abdomen.[94] On a different occasion, "three partner force soldiers suffered from a dismounted improved explosive device (IED), gunshot wound (GSW) injury, and a roll-over motor vehicle crash (MVC)."[95] They arrived at the mission support site from point of injury. Triage was performed by a GHOST-T surgeon and a SORT physician. The patient who suffered the most severe injury had a posterior neck gunshot wound. The patient was moved to the GHOST-T room. The second patient had a gunshot wound to the angle of the mandible without compromising the airway while the third patient had multiple superficial fragmentation injuries. These two patients were not in severe condition, which made their evaluation and treatment in the SORT room necessary.

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93 Nam et al., 118.

94 Nam et al., 119.

95 Nam et al., 119-20.

The presence of both the SORT and GHOST-T teams prevented a mass casualty scenario. The teams' effectiveness was confirmed when delays in the host nation MEDEVAC extended the evacuation of patients to up to two hours. The GHOST-T would have been incapacitated by the delay in the absence of the augmented capabilities resulting from the presence of the SORT team.[96] The SORT team ensured that the GHOST-T remained committed to its mission and their work confirmed that the two teams could collaborate at a remote location when supported by SOF. SORT helps not only with DCR but also with the provision of critical care to patients. Cases of two or more patients requiring simultaneous resuscitative endovascular balloon occlusion of the aorta (REBOA) are expected in an operation, and thus the SORT must focus on DCR as well as advanced procedures such as REBOA placement. The SORT can also help the light GHOST-T manage and implement various tasks involved in caring for such patients.

The SORT did more than help to extend the golden hour; it also provided additional medical coverage to ODAs. The ODAs used the mission support site as jumping-off point for combat missions, resulting in additional medical coverage. For instance, the SORT physician and SOCMs would go on a helicopter assault force mission with the objective of occupying compounds of interest.[97] The presence of the SOCM gave the ODA medical sergeants ample time and allowed them to pay attention to their tactical responsibilities. More advanced procedures would be carried out near the point of injury. The tactical medical expertise of the medical sergeants ensured that SOCMs remained in high demand because they would go with the ODAs on combat patrols and missions during the period of deployment. From the perspective of a surgeon, the combination of the SORT and GHOST-T led to added capabilities for resuscitation and triage while ensuring that a small, mobile footprint was maintained. GHOST teams are likely to become incapable during a mission when positioned alone, as they care for a surgical patient and face resource problems. On the other hand, an isolated SORT does not have the ability to perform advanced hemostasis and surgical procedures. Combining the SORT and GHOST-T teams

96 Nam et al., 119-20.

97 Nam et al., 120.

results in a balance of the medical rules as well as operational tempo, which leads to reduced surgical procedures and prevents the over-deployment of limited resources.[98]

The presence of the two teams also led to sharing of ideas, equipment, and best practices. The SORT equipment best compares with equipment of ODAs that GHOST-Ts because of its alignment with 1st Special Forces Command. However, SORT comes with advanced optics, light vision devices, and lighter body armor, which enhances the team's effectiveness in austere areas.[99] SORT's commercial-off-the shelf freezer also allowed them to store blood for a longer time, and its handheld ultrasound fostered easier and nimbler point-of-care ultrasound. Additionally, SORT's extensive pre-deployment tactical training enhanced its effectiveness during the operation. On the other hand, GHOST-T came in with enhanced mobility. Its lightweight tactical all-terrain vehicle enhanced the easy of being transported by CH47 rotary wing aircraft.[100] This was of great use to SORT when they needed to move equipment from one point to another by hand or rickshaw.

The summer fighting season in Afghanistan shows that effective DCR and DCS is critical for military medicine. It is important for medical teams to work as experts in the provision of prolonged field care, which requires nursing skills and critical care medicine in environments with limited resources. This confirms the need to combine two important medical teams, SORT and GHOST-T, to collaborate in an austere mission support site, with the support of SOF, to help extend the golden hour. Placing these two teams together increases the range of medical capabilities at the battlefield and provides teams with the opportunity to share ideas and resources.

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98 Nam et al., 119-20.

99 Nam et al., 120.

100 Nam et al., 120.

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V. CONCLUSION AND RECOMMENDATIONS

The principal objective of this thesis was to use the systematic reviews approach to examine the validly of the sixty-minute evacuation standard—or golden rule policy—on the mortality of combat-related trauma patients. In doing so, it also assessed the feasibility of offsetting that finite time standard and alleviating its operational constraints by situating mobile resuscitative surgical elements and individual warfighters proficient in TCCC close to the forward edge of battle. Moreover, the paper has evaluated the practicality and applicability of the sixty-minute standard as a planning consideration for future operations. It examined how battlefield medical care and evacuation have evolved, highlighted how the golden hour policy was devised and implemented, and discussed the results of the policy's enforcement on military operations in Afghanistan in 2009, which are connected to its contemporary utility. The recommendations in this chapter have been analyzed using the capability-need review criteria, which strive to uncover existing gaps in competence. They are also suitable, and feasible, for use on modern battlefields.

Although the golden hour rule has been popular among civilian trauma practitioners, this popularity comes not from empirical data but from anecdotes, and from the claims of a famous surgeon who encouraged his colleagues to observe the standard. More importantly, most of the quantitative studies that sought to determine the concept's validity ended up questioning its entire existence. Even though most of these studies could not find a strong positive correlation between the principle and patient outcomes, medical experts still insist that it is important for trauma patients to access definitive care within sixty minutes. Applications on the battlefield established that this logic does not significantly impact combat mortality rates or chances of survival. When injured servicemembers receive high-quality care close to the points of injury and during transportation, they are less likely to die from their injuries within the initial two hours. In fact, the systematic review confirmed that expediting the evacuation of critically injured soldiers to meet a sixty-minute standard would not improve their future outcomes. Rather, it is the quality of initial-point-of-injury primary care that is critical for survivability; thus,

when it comes to establishing military polices to reduce mortality rates, prehospital care is more important than prompt evacuation times.

This systematic review also discovered that the military has not clearly defined how long typical medical evacuations should take. The U.S. policy does, however, demonstrate an understanding of the need to tailor every prehospital time to the nature and extent of the servicemember's injury. Requiring the golden hour rule as a one-size-fits-all strategy is risky because critical windows tend to vary depending on the type or severity of trauma. The part of the body that has been injured plays a critical role in determining servicemembers' chances of survival, whether or not they reach definitive care in less than an hour. Critics of the golden hour standard acknowledge that the policy might be beneficial for civilian populations that experience little if any of the threats of war; on the battlefield, however, there are notably fewer resources, there is a heightened risk of attacks, and there may not be secure evacuation routes. To minimize assumptions and prejudice among stakeholders, it is important to consider that U.S. military policies and guidelines do not unequivocally offer support to the golden hour evacuation principle, and to clarify the value of this standard to the armed forces. Policymakers must consider medical intervention strategies tied to precise empirical data because evidence-based scientific reviews are more likely to optimize the present for favorable future patient outcomes.

It is crucial for the United States to maximize the quality of care provided to injured servicemembers during the first fifteen minutes post-injury; according to the meta-analyses, this is more important than delivering prompt transportation to the nearest trauma facility.[101] For example, when medics supply definitive airway control through rapid sequence induction and intubation, there are marked benefits to the patient's head and airway. Once the airway is secured, the window for patient movement expands to up to two hours while being administered intensive care; much life-saving care can be administered during transportation, including hypotensive resuscitation, blood transfusion, adjunctive clotting factors, antibiotics, analgesics, novel hemostatic, splintage, and FAST

[101] Butler, "Two Decades of Saving Lives on the Battlefield," 172.

scanning.[102] Proficiency in TCCC and damage control surgical intervention at the point of injury can offset the need for unrealistically expedient evacuation.

TCCC proficiency can improve servicemembers' chances of surviving combat-based trauma, and this strategy is feasible with modern medical transport systems. Furthermore, the systematic review in this thesis shows that the golden hour standard can be increased to an average of two hours. The most significant challenge of changing this policy is confronting public perceptions about the value of the golden hour rule; some may see the additional sixty minutes as an insinuation that the government no longer cares about the lives of soldiers. This psychological trap could deter the success of notable medical intervention strategies like the TCCC or the placement of surgical intervention assets closer to the forward edge of operations.

A. JOINT DOCTRINE

It is alarming that the American armed forces, the world's largest superpower, do not have a unifying guideline for how their servicemembers conduct combat-based medical evacuations. The absence of a joint doctrine leaves every wing of the U.S. military grappling for an effective strategy, which in turn leaves some of them to adopt strategies like the golden hour standard, even though it has not been backed by rigorous scientific assessments. Standardized evacuation procedures may significantly reduce the number of lives lost in warfare. If everyone implements similar standards, the scope of research to determine efficacy will improve, thereby improving validity, and it would take more than a commandant who believes in the golden hour rule to reinstate this faulty principle. Increasing the recommended prehospital time to at least two hours will not, by itself, cause more injured servicemembers to die. The military should challenge contemporary assumptions or stereotypes involving the golden hour standard so that medical planners can create practical, effective, and efficient combat health support plans that do not require additional personnel or equipment, and that do not limit the operational range.

[102] Parker, "Casualty Evacuation Timelines," 277.

Based on the research, this thesis recommends a unified joint medical evacuation policy that clearly outlines a practical and applicable standard for evacuation based on empirical data. Arbitrarily following a one-hour guideline puts personnel, equipment, and infrastructure at risk; costs a substantial amount of money; and limits the operational nature and range of the units that are bound by that standard. A unified policy that outlines a realistic time standard would not shortchange servicemembers the care they deserve; such a policy would be further protecting lives and critical infrastructure, and allowing units more autonomy when conducting missions. Strategies such as TCCC can provide the same, if not better, standard of care, while reducing significant risk to life and infrastructure.

B. TCCC TRAINING AND PROFICIENCY

Proficiency in TCCC can offset faster evacuation times because, foundationally, it focusses on treating the most immediate and significant injuries that could lead to death within the first fifteen minutes a servicemember sustains a combat casualty. These significant causes include airway problems, hemorrhage, and pneumothorax.[103] This has had an overwhelmingly positive effect on patient survivability outcomes, demonstrated clearly by the 75th Ranger Regiment's overwhelming success using the tactic in the Afghanistan and Iraq Wars. By maintaining TCCC proficiency, the Ranger Regiment maintained an extremely low death-by-preventable-cause rate; the tactic should thus become the standard prior to deployment for all of U.S. servicemembers.[104] The Ranger Regiment has demonstrated that it is practical and conceivable for everyone to be trained to such a standard. Though units will need resources to facilitate this training—to include time, money, and other allocations—at a minimum for pre-deployment, the return on investment of that time and money is invaluable. Both the initial training course and the refresher course are inexpensive and can be made readily available. Travel for the course is unnecessary, as it can be arraigned at every major military installation. For units that

[103] Andrew D. Fisher et al., "The Ranger First Responder Program and Tactical Emergency Casualty Care Implementation: A Whole-Community Approach to Reducing Mortality from Active Violent Incidents," *Journal of Special Operations Medicine* 15, no. 3 (Fall 2015): 46–53, https://www.jsomonline.org/Subscriber/articles/1503/2015346Fisher.pdf.

[104] Fisher et al., 46-53.

may fall outside of course instruction by organic units, mobile training teams can conduct onsite training.

This thesis recommends that the Army require all soldiers to be trained and proficient in TCCC. Currently, equivalent training is required for only "one member of each team, squad, crew, or equal-sized unit."[105] This recommendation is based on careful consideration of the Ranger Regiment's success and current standard operating procedure. Having all members of a unit be proficient in TCCC will significantly reduce the possibility of incomplete or improper care to wounded personnel in the crucial fifteen minutes after injury, before a more advanced trained combat medic arrives or the servicemember can be evacuated for surgical intervention.[106] Improved quality of care at the individual level will directly correlate to lives saved in combat operations; to achieve this, every unit should allocate the necessary time and money.

C. MOBILE SURGICAL TEAMS

Reexamining how units are employed on the battlefield can also have a significant impact on reducing mortality rates and offsetting the need for shorter evacuation times. Today, mobile surgical teams can be positioned close to the forward edge of battle with fewer limitations and support requirements than ever before. When these teams are positioned close to the point of injury, they have been effective for much the same reasons that TCCC training has been effective; rather than relying on moving the patient to a higher level of care faster, these teams provide more immediate damage control resuscitation to treat the most significant life-threating injuries, and do so with lower risk to human resources and infrastructure.

Doctrinal units within conventional forces have the capability to attach to a maneuver company or service-equivalent-size element's medical asset. Additionally, these units can be broken out further into smaller, more mobile teams with an even smaller

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[105] Army Institute for Professional Development, "Combat Lifesaver Course: Student Self-Study," Shasta Defense, accessed August 17, 2020, http://www.shastadefense.com/IS0871-CALMS.pdf.

[106] Fisher et al., "The Ranger First Responder Program," 53.

footprint and logistical requirement. While these teams exist primarily in special operations forces currently, the blueprint for success has already been established and could be replicated easily for conventional maneuverer forces as well. These even smaller teams can maneuverer with the lightest ground elements and provide an even more immediate lifesaving resuscitative capability. Employing surgical capabilities closer to the potential point of injury can significantly reduce evacuation times and distances to damage control surgery, which will subsequently improve outcomes without relying on direct evacuation to a Level III facility. The U.S. Army's current force projections show an end strength of thirty-one active duty brigade combat teams plus twenty-seven National Guard brigade combat teams; ideally, each brigade combat team or equivalent should be supported by at least two mobile surgical capabilities.[107] This alignment of forward surgical teams should be permanent, and training should be conducted routinely with the supported unit so they can provide seamless coordination of care once deployed.

D. TRAINING AND EDUCATION

This thesis recommends changes to training and education rather than changes to supplies or equipment. While equipment certainly affects the survivability of patients, it is outside the scope of this research to evaluate emerging medical technologies; doing so will require formal research about the application of equipment in the effort to offset the golden hour. Instead, this thesis recommends changing the way leaders are taught to plan and to manage subordinate and support units, and recommends new or refreshed medical training requirements for servicemembers across the branches. Most military leaders believe the golden hour is a necessary and absolute requirement to prevent or reduce combat deaths. Though refuted, this perception has strong backing and is deeply seated in the minds of leaders and planners. Decision-makers must be presented with the evidence that disproves such a requirement if a paradigm shift is to happen regarding this medical standard. This

[107] Claudette Roulo, "Army to Cut 12 Brigade Combat Teams by 2017, Odierno Says," Department of Defense, June 25, 2013, https://archive.defense.gov/news/newsarticle.aspx?id=120361; U.S. Army Force Management System, accessed June 21, 2019, https://fmsweb.army.mil/unprotected/splash.

will require a thorough overhaul in the curriculum at all levels and the way that planning for combat operations is taught in military schoolhouses.

E. CONCLUSION

The field of medicine, especially when it comes to best practices for treating trauma victims, is a continuously evolving. It is imperative for the military to constantly evaluate and adapt to the newest protocols and modify its praxis to ensure the services are keep abreast of such changes and revise policy and doctrine accordingly.

The current and unchallenged standard, first enacted by Secretary Gates and continuously perpetuated in operational planning circles, that all operations conducted by U.S. forces must be done inside a sixty-minute evacuation window to a Level III facility has to change. This one-hour limit is not based on scientific evidence and is not a feasible standard, as it limits operational reach when it comes to ground combat forces. Instead, TCCC proficiency and mobile surgical resuscitation teams employed to the forward edge of combat can more practically save lives on the battlefield.

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