The Effect of Preexisting Medical Comorbidities on Trauma Outcomes in Milwaukee, Wisconsin: A Retrospective Hospital Database Review.

Universidad de Oviedo

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Statement

I hereby certify that this thesis entitled “The Effect of Preexisting Medical Comorbidities on Trauma Outcomes in Milwaukee, Wisconsin: A Retrospective Hospital Database Review.” is my own work. All the sources of information reported by others are indicated in the list of references according to the guidelines.

(Signature)

I, Ihsan Shawki Akili, approve the thesis for submission.

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Abstract

Background: Traumatic injuries are a major public health challenge worldwide. The proportion of trauma patients with preexisting medical comorbidity has increased dramatically in recent years due to the aging population. While most studies agree on the negative effect of comorbidities on mortality rates, focusing only on mortality excludes the 95% of trauma cases that survive. Few studies, if any, have examined hospital lengths of stay for trauma patients with different comorbidities.

Methods: This retrospective study included trauma patients who were admitted to Froedtert Hospital (Milwaukee, WI, USA) in the period between 2015 to 2023. A total of 8,365 patients were included. Preexisting medical comorbidities effect on length of hospital stay, intensive care unit (ICU) stay, and ventilator use status were examined using multiple logistic regression for categorical variables, and analysis of covariance (ANCOVA) for numerical variables. All results were adjusted for potential confounders (age, gender, injury type, and Injury Severity Score)

Results: Medical comorbidities significantly increased the hospital length of stay by an average of 1.42 days. Obesity had the greatest effect, adding 4.36 days, followed by cardiovascular disease at 3.13 days. Other comorbidities also showed significant association, ranging from 1 to 3 additional days. Additionally, medical comorbidities significantly increased ICU stay by an average of 0.27 days. Again, obesity had the greatest effect, adding 1.43 days, followed by substance and drug use disorders at 0.76 days. Other comorbidities showed significant associations of 0.5 to 1 additional days. However, medical comorbidities were not associated with a significant increase in ventilator use status or duration, except for substance and drug use disorders, which increased the odds of ventilator use by 30%, and obesity, which increased the duration of ventilator use by 0.79 days.

Conclusion: Medical comorbidities significantly affect hospital length of stay and intensive care unit stay. Management protocols for trauma patients with comorbidities that include comprehensive, multidisciplinary teams to assist with comorbidity management may improve outcomes and reduce costs. Further research is needed to examine the outcome effects of individual comorbidities and the best ways to manage them.

Keywords: medical comorbidities, trauma outcomes, hospital length of stay, ICU length of stay, ventilator use, emergency medicine.

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Abbreviations

ADHD - Attention-Deficit/Hyperactivity Disorder

COPD - Chronic Obstructive Pulmonary Disease

DALY - Disability-Adjusted Life Year

DBP - Diastolic Blood Pressure

EMS - Emergency Medical Services

GCS - Glasgow Coma Scale

HR - Heart Rate

ICU - Intensive Care Unit

MOI - Mechanism of Injury

MVC - Motor Vehicle Crash

RR - Respiratory Rate

SBP - Systolic Blood Pressure

SO2 - Oxygen Saturation

WHO - World Health Organization

TBI - Traumatic Brain Injury

ISS - Injury Severity Score

HIPAA - Health Insurance Portability and Accountability Act

CHF - Congestive Heart Failure

CVA - Cerebrovascular Accident

MI - Myocardial Infarction

PAD - Peripheral Arterial Disease

ED - Emergency Department

CI - Confidence Interval

AIS - Abbreviated Injury Scale

MISS - Modified Injury Severity Scale

ANCOVA - Analysis of Covariance

SD - Standard Deviation

PD - Parkinson's Disease

MS - Multiple Sclerosis

IQR - Interquartile Range

AMA - Against Medical Advice

LOS - Length of Stay

CVD - Cardiovascular Disease

OR - Odds Ratio

CDC - Centers for Disease Control and Prevention

DM - Diabetes Mellitus

BMI - Body Mass Index

Introduction

Traumatic injuries are still a major public health challenge, and one of the leading causes of morbidity and mortality worldwide. This is mainly due to their sudden onset and potential for severe, long-lasting consequences. According to the World Health Organization (WHO), injuries, including both unintentional and violence-related events, cause the deaths of approximately 4.4 million individuals globally each year, which accounts for nearly 8% of all deaths across all age groups (1). Furthermore, road injuries were ranked as the 7th highest cause of disability-adjusted life years (DALYs) lost worldwide, surpassing even diabetes (ranked 10th), tuberculosis (ranked 12th), and malaria (ranked 14th) (2). In the United States (US), motor vehicle crashes (MVCs) remain the leading cause of mortality for children and adolescents. In 2020 alone, more than 63,000 children were injured and another 711 lost their lives due to road crashes (3).

Traditionally, young adults and teenagers are more commonly injured, while older adults are more prone to non-communicable diseases and their complications. However, this pattern is changing due to the global trend of population aging. The mean age of trauma patients is on the rise, along with the prevalence of trauma patients with medical comorbidities (4). Based on a nationwide longitudinal study, the average age of trauma patients who were discharged from an American hospital rose from 54.08 in 2000 to 59.58 in 2011(5). Furthermore, according to a decade-long study involving approximately 1.5 million trauma patients, the number of trauma patients over the age of 65 with at least one medical comorbidity more than doubled, rising from 88,056 in 2007 to 158,929 in 2015 (6).

Considering the current trend of population aging, trauma care systems are challenged with diminished physiological reserves and pre-existing comorbidities in elderly patients. Patients with comorbidities often face worse outcomes following a traumatic event. This has been demonstrated in a recent systematic review and meta-analysis that identified comorbidities such as cardiovascular diseases, respiratory diseases, renal diseases, and neurological diseases as major contributors to an increase in-hospital mortality risk (7).

In general, there has been extensive research on traumatic injuries. However, the majority of these studies have primarily focused on a specific injury mechanism and/or type, such as firearm injuries, traumatic brain injuries, blunt or penetrating abdominal injuries but not on specific medical comorbidities (8–12). A systematic review and meta-analysis conducted by Breeding et al. on the association between gender and clinical outcomes in patients with moderate to severe traumatic brain injury (TBI) showed that female patients had a higher mortality risk but shorter hospital length of stay when compared to male patients. However, this research did not address how underlying health conditions might affect these outcomes in TBI patients (8).

Similarly, a meta-analysis by Al Rawahi et al. reviewed the outcomes of selective nonoperative management versus operative management of civilian abdominal gunshot wounds. Although their study did provide critical insights into the efficacy and safety of nonoperative management, it did not investigate the effect of medical comorbidities on these outcomes, which could be crucial for effectively managing such injuries nonoperatively (10). Additionally, a study by Taylor et al. conducted on 2.8 million TBI emergency department visits between 2007 and 2013 found a significant rise in the rate of traumatic brain injuries (TBIs) related to falls among older adults. However, their study lacked an analysis of how comorbidities might affect the severity and outcomes of TBIs (11).

Age has been one of the most studied risk factors for trauma patient death and hospitalization. Several studies has focused on specific age groups, including adolescents and the elderly(13–16). In a systematic review and meta-analysis looking into the predictors of mortality in geriatric trauma patients, Hashimi et al. found that advanced age and severity of injury were significant contributors to mortality risk. However, their study did not investigate how comorbidities could affect trauma outcomes in this population (13). In contrast, most studies on adolescent trauma focused on causes and trends in traumatic brain injuries (TBIs). Their findings showed that motor vehicle crashes were a leading cause of TBIs in adolescents, highlighting the specific risks and injury patterns prevalent in this age group (15,16).

Trauma patients' mortality rate has been one of the most studied trauma outcomes. However, few studies have length of hospital stay, ICU admission or ventilator use as their main outcome measures (5,6,17). A large retrospective cohort study on 1.5 million trauma patients from the US National Trauma Data Bank found improvements in mortality rate among older adult trauma patients between 2009 and 2015. While their findings might have indicated improvement in trauma care in general, it didn't take into account hospital length of stay or ICU admission rates in this population, which are crucial factors for a more comprehensive understanding of trauma outcomes (6). Similarly, a large epidemiological study on trauma-related mortality in the United States from 2002 to 2010, found a decrease in mortality rates for motor vehicle crashes alongside a concerning rise in fall-related mortality. Again, while providing valuable insights into mortality trends, this study did not investigate hospital length of stay or the development of complications (17).

Geriatric trauma patients over the age of 65 had 15% mortality rates compared to 5% in non-geriatric patients, according to a meta-analysis by Hashmi et al. This disparity highlights the need for more comprehensive studies to investigate the reasons behind this higher mortality rate beyond age-related factors (13,18). While these studies do provide some insight, they fail to capture the comprehensive nature of emergency medical care. Focusing only on mortality would exclude the 95% of trauma cases that survive, either with or without complications. A more comprehensive perspective would include surviving patients by also considering outcomes such as hospital lengths of stay or ventilator use (18).

Our study aims to measure the effect of preexisting medical comorbidities, including cardiovascular diseases, respiratory diseases, mental and personality disorders, substance use disorders, neurological diseases, bleeding disorders, and cardiovascular risk factors (including hypertension, diabetes mellitus, obesity and current smoking) on trauma outcomes. The measured outcomes are the length of hospital stay, admission to the intensive care unit (ICU), and ventilator use in trauma patients. Our study findings may allow physicians to anticipate complication development, such as ICU admission and ventilator support, in trauma patients with preexisting comorbidities. It potentially may also facilitate estimates of the overall length of hospital stay for trauma patients with medical comorbidities, enhancing preparedness and patient care strategies.

Methods

Study Design

This study is a retrospective database review of the trauma patient dataset from 2015 to 2023. The data used are from the trauma registry database of Froedtert Hospital (Milwaukee, WI, USA), an American College of Surgeons-verified Level 1 trauma center affiliated with the Medical College of Wisconsin. Froedtert Hospital functions as the largest academic tertiary-care hospital for a region of around a million individuals (19). The Institutional Review Board of the Medical College of Wisconsin (Milwaukee, WI) and the Research Ethics Committee of the Principality of Asturias (Oviedo, Spain) reviewed the study and concluded that it was exempt from oversight.

The following were the inclusion criteria for our study:

1. Any patient with a trauma diagnosis, regardless of the mechanism or type of the injury
2. At least 18 years of age but not over 90 years of age
3. Medical care was provided at the hospital from January 2015 through December 2023

The exclusion criteria were as follows:

1. Patients who are under the age of 18 years
2. Patients who are over the age of 90 years

The following data were obtained for each trauma case:

1. Basic demographic characteristics which included the following variables:
   a. Age in years
   b. Gender
   c. Past medical history (previous medical comorbidities)
   d. Weight and height

2. On-scene and in-hospital examination findings which included the following variables:
   a. Mechanism of injury (fall, MVC, gunshot wound, assault, motorcycle, pedestrian, stab wound)
   b. Injury type (blunt, penetrating, burn)
   c. EMS vital signs
      i. Systolic blood pressure (SBP)
      ii. Diastolic blood pressure (DBP)
      iii. Respiratory rate (RR)
      iv. Hear rate (HR)
      v. Oxygen saturation (SO2)
      vi. Glasgow Coma Scale (GCS)
   d. In-hospital vital signs
      i. SBP
      ii. DBP
      iii. HR
      iv. SO2
      v. GCS
   e. Injury Severity Score (ISS)

    f. Location of noted injuries to head, neck, torso, or extremities

3. Hospitalization outcome
    a. Length of hospital stay (number of days)
    b. Post emergency department disposition (floor, intensive care unit, operating room, home, morgue)
    c. Discharge status (alive or dead)
    d. Intensive care unit (ICU) admission status
    e. ICU length of stay (number of days)
    f. Ventilator use status (yes or no)
    g. Length of ventilator use (days)

The following previous medical comorbidities were recorded in the trauma registry database and were extracted for this study:

Alcohol Use Disorder
Angina Pectoris
Anticoagulant Therapy
Asthma
Attention Deficit Disorder/Attention Deficit Hyperactivity Disorder
Bleeding Disorder
Cancer
Cerebral Vascular Accident (CVA)
Chronic Obstructive Pulmonary Disease (COPD)
Chronic Renal Failure
Cirrhosis
Congestive Heart Failure (CHF)
Coronary Artery Disease
Current Smoker
Dementia
Diabetes Mellitus
Drug Use Disorder
Hypertension
Mental/Personality Disorders
Multiple Sclerosis
Myocardial Infarction (MI)
Obesity
Parkinson's Disease
Peripheral Arterial Disease (PAD)
Seizures
Steroid Use
Substance Use Disorder

The data elements mentioned above were extracted from the hospital trauma registry database and compiled into a separate, secure study database by authorized database managers who were not part of the study team. During this process, all 18 identifiers specified by the Health Insurance Portability and Accountability Act (HIPAA) were removed before the data were transferred to the study database. HIPAA regulations specify that age over 90 years is considered a personal identifier, which is why our study excluded patients over the age of 90 years. The study investigators had access to this separate study database only, and they did not have any direct access to the trauma registry database. The data were then organized into an Excel spreadsheet and then later converted to an SPSS file.

Statistical Methods and Analysis

SPSS version 26 was used to analyze the data. Due to the small sample sizes for several conditions, the investigators could not study each disease individually. Instead, the investigators grouped the medical comorbidities into the following categories to reduce data fragmentation. If a patient had more than one comorbidity, they were included in more than one group:

1. Cardiovascular diseases, which included Coronary artery disease, Congestive Heart Failure (CHF), Myocardial Infarction (MI), Angina Pectoris and/or Peripheral arterial disease.
2. Respiratory diseases, which included Asthma and/or Chronic Obstructive Pulmonary Disease (COPD).
3. Mental and personality disorders, which included Mental/Personality Disorders, and/or Attention Deficit Disorder/Attention Deficit Hyperactivity Disorder.
4. Substance use disorders, which included Substance Use Disorder, Drug Use Disorder, and/or Alcohol Use Disorder.
5. Neurological diseases, which included Cerebral Vascular Accident (CVA), Seizures, Dementia, Multiple Sclerosis, and/or Parkinson's Disease.
6. Bleeding disorders, which included Bleeding Disorder and/or Anticoagulant Therapy.
7. Cardiovascular risk factors, which included Hypertension, Obesity, Current Smoker and/or Diabetes mellitus.
8. Other diseases, which included Cancer, Chronic renal Failure, Steroid Use and/or Cirrhosis.

To categorize the severity of the injury, the following accepted standard categories were used based on the Injury Severity Score. Injury Severity Scores of 1–8 were considered mild injuries, 9–15 moderate, 16–24 severe, and 25 or higher critical injuries (20). The Injury Severity Score (ISS) is one of the most widely used scoring systems in trauma research, correlating strongly with key outcomes such as mortality and length of hospitalization. The ISS provides a very effective way to characterize patients with multiple injuries. It is based on the Abbreviated Injury Scale (AIS), which assesses injury severity across different body regions (21). For example, the ISS considers the AIS scores of the three most severely injured body regions: A (head, neck, and face), B (thorax and abdomen), and C (extremities, including the external pelvis). ISS=(A)2+(B)2+(C)2. The ISS ranges from 0 to 75, with the maximum score indicating the most severe injuries. If any of the three AIS scores is a 6, the ISS is automatically set to 75, as a score of 6 signifies an unsurvivable injury. Although there are other trauma scoring systems, such as the modified ISS (MISS), which includes the Glasgow Coma Scale (GCS), and the New ISS, evaluations of these modified scores have not demonstrated significant advantages over the standard ISS. Therefore, the ISS was used as a controlling variable for injury severity (22,23).

Firstly, the following descriptive statistics of demographic characteristics and in-hospital examination findings were calculated. For continuous, normally distributed variables, the mean and standard deviation were calculated. For non-normally distributed variables, the median and interquartile range were calculated. Normality of the data was assessed using the Shapiro-Wilk test and by examining skewness and kurtosis in the histograms. For categorical variables such as previous medical comorbidities, frequencies, and percentages relative to the column population were used.

1. Average age of trauma patients
2. Total number of trauma patients
3. Percentage of patients by gender
4. Percentage of patients by each injury type
5. Percentage of patients by each mechanism of injury
6. Percentage of patients by each previous medical comorbidity
7. Percentage of patients by each cardiovascular risk factors

Secondly, using the same principles, the investigators calculated the following descriptive statistics of hospitalization outcome data.

1. Median of the Injury Severity Score
2. Percentage of patients in each ISS category (Mild ≤8, Moderate 9-15, Severe 16-24, Critical ≥25)
3. Percentage of patients by Post Emergency Department (ED) disposition
4. Percentage of patients in each injury severity category stratified by mechanism of injury
5. Mortality rate
6. Median hospital length of stay (days)
7. Percentage of patients who required ICU admission
8. Median ICU stay duration (days)
9. Percentage of patients who required ventilator use
10. Median ventilator use duration (days)

Using basic inferential statistics, differences in numerical variables across categories were tested using independent sample t-tests for normally distributed data and Mann-Whitney U tests for non-normally distributed data. Categorical variables and percentages were tested using the Chi-square test. Statistical significance in group differences were set at a p-value of 0.05 with 95% confidence intervals (CIs).

Using multivariable inferential statistics, the investigators studied the effect of previous medical comorbidities (independent variable) on various trauma outcome variables (dependent variables), including length of hospital stay in days, ICU admission state, number of days spent in the ICU, ventilator use, and number of days on the ventilator. The analysis was conducted in three separate steps. In each step, the investigators controlled for confounders, including age, gender, injury type, and Injury Severity Score.

In the first step of analysis, the investigators studied the effect of having any medical comorbidity (independent variable) compared to the reference group with no previous medical comorbidities on the outcome variables. Multiple logistic regression was used to analyze ICU admission state and ventilator use state, while analysis of covariance (ANCOVA) was used for length of hospital stay, number of days in the ICU, and number of days on the ventilator. The statistical significance level for outcome measures was set at a p-value of 0.05 with 95% confidence intervals (CIs). For clinical significance, a difference of at least 10% more or less than the reference group was considered clinically meaningful.

In the second step of analysis, using the same principles described above, the investigators studied each of six preexisting diseases categories (cardiovascular diseases, respiratory diseases, mental and personality disorders, substance use disorders, neurological diseases, and bleeding disorders) compared to the reference group with no previous medical comorbidities on the outcome variables. The researchers did not study the effect of the other diseases category on trauma outcomes as the number of cases is too low for any statistical significance and the disease profiles are not uniform between these diseases. Furthermore, all missing data were excluded from our analysis and no data imputation was done. The investigators also studied the combined effect of cardiovascular and respiratory diseases on trauma outcomes, considering potential synergistic interactions that could establish a cause-effect gradient for adverse outcomes. However, exploring other combinations involving other categories was not considered as feasible due to the diverse nature of the diseases (24).

In the third step of analysis, using the same principles described above, the investigators studied each of the four cardiovascular risk factors (hypertension, diabetes mellitus, obesity and current smoking), on trauma outcomes compared to the reference group with no previous medical comorbidities on the outcome variables. Additionally, the investigators explored the effect of having one versus two, three, or all four cardiovascular risk factors on the outcome variables. This approach is supported by numerous studies highlighting the synergistic effects of cardiovascular risk factors (25).

Results

General demographic characteristics

A total of 8,365 patients were included in the study, with a predominance of males (N=5,402, 64.6%) over females (N=2,963, 35.4%). The mean age of the patients was 50.9 years (SD=21.1), with the male population significantly younger than the female population, averaging 47.1 years vs. 57.8 in females, and a p value of <0.001. Blunt injuries were the most common injury type overall, accounting for 83.2% (N=6,959) of the total injuries. Penetrating injuries were the second most common injury type at around 16.7% (N=1,400), while burns were the least common, at 0.1% (N=6). A significant gender difference was noted in the distribution of injury types with blunt injuries being more common in females (92.6%) compared to males (78.0%, $p<0.001$). In contrast, penetrating injuries were more common among males (21.9%) than females (7.4%, $p<0.001$).

Falls were the most common cause of injury overall, representing 39.8% (N=3,329) of cases, with a higher prevalence in females (54.5%) compared to males (31.7%, $p<0.001$). Motor vehicle collisions (MVCs) were the second most common injury mechanism at 22.2% (N=1,859), followed by gunshot wounds (10.3%, N=858) and assaults (4.8%, N=404). Again, a significant gender difference was noted in the mechanism on injuries with males showing a higher prevalence of gunshot wounds (13.9%) and assaults (5.9%) compared to females (3.6% and 2.9%, respectively). Other mechanisms of injury included motorcycle crashes (5.1%), pedestrian incidents (4.6%), stab wounds (3.7%), and other miscellaneous causes (9.6%). Refer to table {1}.

Overall, 71.3% (N=5,968) of the total population had at least one preexisting medical comorbidity. A significantly higher prevalence was noted in females (78.4%) compared to males (67.5%, $p<0.001$). Cardiovascular diseases were present in 5.3% (N=444) of the trauma population with a higher prevalence in females (7.2%) compared to males (4.3%, $p<0.001$). Respiratory diseases were present in 6.4% (N=534) of the population, with a significantly higher prevalence in females (9.0%) compared to males (5.0%, $p<0.001$). Substance and drug use disorders were present in 12.8% (N=1,074) of the overall population, with males showing a higher prevalence (14.1%) compared to females (10.5%, $p<0.001$). Neurological diseases were found in 10.5% (N=875) of patients, with a higher prevalence in females (15.1%) compared to males (7.9%, $p<0.001$). Mental and personality disorders were identified in 22.5% (N=1,881) of the population, with females exhibiting a significantly higher prevalence (30.6%) compared to males (18.0%, $p<0.001$). Bleeding disorders were present in 8.9% (N=747) of patients, with a higher prevalence in females (10.4%) compared to males (8.1%, $p<0.001$). Other medical conditions, including cancer, chronic renal failure, and cirrhosis, were noted in 3.9% (N=323) of the total population, with females having a higher prevalence (5.1%) compared to males (3.2%, $p<0.001$). Refer to table {1}.

Cardiovascular risk factors were also analyzed. Hypertension was present in 35.5% (N=2,972) of the total population, with a higher prevalence in females (44.0%) compared to males (30.9%, $p<0.001$). Diabetes mellitus was found in 14.2% (N=1,187) of patients, with a higher rate in females (17.2%) compared to males (12.5%, $p<0.001$). Obesity affected 5.7% (N=480) of patients, with a higher rate in females (7.6%) compared to males (4.7%, $p<0.001$) and current smoking was reported by 26.9% (N=2,252) of the population, with males having a higher smoking rate (30.2%) than females (20.9%, $p<0.001$). Refer to table {1}.

Table {1}: demographics, injury type, preexisting medical comorbidities, and cardiovascular risk factors of trauma patients, stratified by gender.

Variables	Total patients (N=8365)	Male (N=5402,64.6%)	Female (N=2963,35.4%)	p-value
Age (years) ± SD	50.9 ±21.1	47.1±19.7	57.8±21.7	<0.001
Injury type (%)				
- Blunt	6959 (83.2%)	4215 (78.0%)	2744 (92.6%)	<0.001
- Penetrating	1400 (16.7%)	1182 (21.9%)	218 (7.4%)	
- Burn	6 (0.1%)	///////////////	////////////	
Mechanism of Injury (%)				
- Fall	3329 (39.8%)	1714 (31.7%)	1615 (54.5%)	
- MVC	1859 (22.2%)	1106 (20.5%)	753 (25.4%)	
- Gunshot Wound	858 (10.3%)	752 (13.9%)	106 (3.6%)	
- Assault	404 (4.8%)	318 (5.9%)	86 (2.9%)	<0.001
- Motorcycle	423 (5.1%)	376 (7.0%)	47 (1.6%)	
- Pedestrian	382 (4.6%)	248 (4.6%)	134 (4.5%)	
- Stab Wound	306 (3.7%)	240 (4.4%)	66 (2.2%)	
- Others	804 (9.6%)	648 (12.0%)	156 (5.3%)	
Previous Medical Comorbidities (%)	5968 (71.3%)	3646 (67.5%)	2322 (78.4%)	<0.001
- Cardiovascular Diseases (CHF, MI, PAD, Angina)	444 (5.3%)	230 (4.3%)	214 (7.2%)	<0.001
- Respiratory Diseases (COPD, Asthma)	534 (6.4%)	268 (5.0%)	266 (9.0%)	<0.001
- Substance and Drug Use Disorder including Alcohol	1074 (12.8%)	763 (14.1%)	311 (10.5%)	<0.001
- Neurological Diseases (PD, CVA, MS, Seizures, Dementia)	875 (10.5%)	428 (7.9%)	447 (15.1%)	<0.001
- Mental and personality Disorder including ADHD.	1881 (22.5%)	975 (18.0%)	906 (30.6%)	<0.001
- Bleeding Disorders including the use of Anticoagulant	747 (8.9%)	439 (8.1%)	308 (10.4%)	<0.001
- Other diseases (Cancer, Chronic renal Failure, Cirrhosis)	323 (3.9%)	173 (3.2%)	150 (5.1%)	<0.001
Cardiovascular risk factors (%)				
- Hypertension	2972 (35.5%)	1668 (30.9%)	1304 (44.0%)	<0.001
- Diabetes Mellitus	1187 (14.2%)	676 (12.5%)	511 (17.2%)	<0.001
- Obesity	480 (5.7%)	255 (4.7%)	225 (7.6%)	<0.001
- Current Smoker	2252 (26.9%)	1633 (30.2%)	619 (20.9%)	<0.001

Hospitalization course and outcome analysis

Trauma patients' hospitalization course and outcome were studied. The median Injury Severity Score (ISS) for the total population was 9 (IQR: 4-16). Males showed a higher median ISS of 9 (4-17) compared to females with an ISS of 9 (4-13) ($p < 0.001$). Also, out of the total population, 37.1% had a mild injury corresponding to an ISS ≤8, 35.5% had a moderate injury (ISS 9-15), 15.2% had a severe injury (ISS 16-24), and 12.3% had a critical injury (ISS ≥25). In males, 35.3% had a mild injury, 33.9% had a moderate injury, 16.8% had a severe injury, and 14.0% had a critical injury. However, in females, 40.4% had a mild injury, 38.4% had a moderate injury, 12.3% had a severe injury, and 9.0% had a critical injury ($p < 0.001$). Females had higher proportions in the mild (ISS ≤ 8) and moderate (ISS 9-15) categories, while males had higher proportions in severe (ISS 16-24) and critical (ISS ≥ 25) categories ($p < 0.001$). Refer to table {2}.

Out of the total population, 44.4% of patients were admitted to the floor, 23.0% to the intensive care unit (ICU), 19.1% to the operating room, 3.1% were discharged home, 1.2% to the morgue, and 9.2% to other destinations (including leaving against medical advice or being transferred to correctional facilities). Among males, 39.9% were admitted to the floor, 24.5% to the ICU, 22.0% to the operating room, 3.8% were discharged home, 1.6% to the morgue, and 8.1% to other destinations. However, in females, 52.4% were admitted to the floor, 20.1% to the ICU, 13.8% to the operating room, 2.0% were discharged home, 0.5% to the morgue, and 11.2% to other destinations ($p < 0.001$). The overall fatality rate was 4.8%, with males experiencing a higher rate (5.3%) compared to females (3.7%, $p < 0.001$). Refer to table {2}.

The median hospital length of stay in the total population was 4 days (IQR: 2-7). Males had a shorter median length of stay at 3 days (1-7) compared to females at 4 days (2-7) ($p < 0.001$). ICU admission was required for 34.3% of the total patients, with a higher rate in males (37.1%) when compared to females (29.2%) ($p < 0.001$). The median duration of ICU stay for the total population was 3 days (2-5). Conversely, males had a slightly longer median ICU stay of 3 days (2-5) compared to females at 2 days (2-4) ($p < 0.001$). Ventilator use was required for 13.5% of the patients, with males again showing a higher prevalence (15.9%) compared to females (9.3%) ($p < 0.001$). The median duration of ventilator use for the total population was 3 days (1-7), with males having a higher median of 3 days (2-8) compared to females at 2 days (1-6) ($p < 0.001$). Refer to table {2}.

Table {2}: hospitalization course and outcomes of trauma patients stratified by gender.

Variables	Total patients (N=8365)	Male (N=5402,64.6%)	Female (N=2963,35.4%)	p-value
Injury Severity Score (IQR)	9 (4-16)	9 (4-17)	9(4-13)	<0.001
Injury Severity Score (%) - Mild ≤8 - Moderate 9-15 - Severe 16-24 - Critical ≥ 25	 3099 (37.1%) 2956 (35.5%) 1270 (15.2%) 1024 (12.3%)	 1903 (35.3%) 1829 (33.9%) 907 (16.8%) 757 (14.0%)	 1196 (40.4%) 1136 (38.4%) 363 (12.3%) 267 (9.0%)	<0.001
Post ED Disposition (%) - Floor - Intensive care unit - Operating room - Home - Morgue - Others (AMA, Correctional Facility)	 3712 (44.4%) 1921 (23.0%) 1598 (19.1%) 263 (3.1%) 99 (1.2%) 772 (9.2%)	 2158 (39.9%) 1326 (24.5%) 1189 (22.0%) 204 (3.8%) 85 (1.6%) 440 (8.1%)	 1554 (52.4%) 595 (20.1%) 409 (13.8%) 59 (2.0%) 14 (0.5%) 332 (11.2%)	<0.001
Fatality Rate (%)	398 (4.8%)	287 (5.3%)	111 (3.7%)	<0.001
Hospital Length of Stay (days, IQR)	4 (2-7)	3(1-7)	4(2-7)	<0.001
ICU Admission (%)	2864 (34.3%)	2000 (37.1%)	864 (29.2%)	<0.001
ICU Stay Duration (days, IQR)	3 (2-5)	3 (2-5)	2 (2-4)	<0.001
Ventilator Use (%)	1130 (13.5%)	856 (15.9%)	274 (9.3%)	<0.001
Ventilator Use Duration (days, IQR)	3 (1-7)	3 (2-8)	2 (1-6)	<0.001

The distribution of Injury Severity Score (ISS) categories across different mechanisms of injury were analyzed. For falls, which accounted for the largest subgroup (N=3325), the majority of patients had mild (36.6%) or moderate (40.3%) injuries, with fewer patients having severe (14.1%) or critical (9.0%) injuries. Motor vehicle collisions (MVC), the second largest subgroup (N=1858), showed a higher proportion of critical injuries (16.8%) compared to falls, with still mild (31.4%) and moderate (33.8%) injuries being more common. Gunshot wounds (N=858) had a distinct distribution, with moderate (40.1%) and critical (18.9%) injuries being the two most prevalent. Stab wounds (N=306) had a high proportion of mild injuries (56.5%), while critical injuries were relatively rare (3.3%). Assaults (N=404) displayed a similar trend with the majority of injuries being mild (54.7%) and moderate (27.0%), and a smaller percentage of severe (10.9%) and critical (7.4%) injuries. Motorcycle crashes (N=422) had a significant portion of patients in the severe (21.6%) and critical (19.0%) categories. Pedestrian injuries (N=381) also showed a high proportion of severe (21.5%) and critical (21.3%) injuries. Other mechanisms of injury (N=804) had the highest proportion of mild injuries (60.0%) among all categories, with fewer moderate (24.1%), severe (9.8%), and critical (6.1%) injuries. Refer to table {3}.

Table {3}: injury severity scoring distribution by mechanism of injury.

ISS category	Falls (N=3325, 39.8%)	MVC (N=1858, 22.2%)	Gunshot (N=858, 10.3%)	Stab wound (N=306, 3.7%)	Assault (N=404, 4.8%)	Motorcycle (N=422, 5.1%)	Pedestrian (N=381, 4.6%)	Others (N=804, 9.6%)	Total
Mild	1216 (36.6%)	583 (31.4%)	213 (24.8%)	173 (56.5%)	221 (54.7%)	104 (24.6%)	107 (28.1%)	482 (60.0%)	3099 (37.1%)
Moderate	1339 (40.3%)	628 (33.8%)	344 (40.1%)	93 (30.4%)	109 (27.0%)	147 (34.8%)	111 (29.1%)	194 (24.1%)	2965 (35.5%)
Severe	470 (14.1%)	335 (18.0%)	139 (16.2%)	30 (9.8%)	44 (10.9%)	91 (21.6%)	82 (21.5%)	79 (9.8%)	1270 (15.2%)
Critical	300 (9.0%)	312 (16.8%)	162 (18.9%)	10 (3.3%)	30 (7.4%)	80 (19.0%)	81 (21.3%)	49 (6.1%)	1024 (12.3%)

Hospitalization course and outcome by previous medical comorbidity was also studied. Patients with positive medical comorbidities were older (mean age 55.8 years, ±20.5) compared to those without comorbidities (mean age 38.7 years, ±17.1). Furthermore, the median ISS was 9 (IQR 4-16) for the total population. Patients with positive medical comorbidities had a median ISS of 9 (IQR 4-16), while those without comorbidities had a slightly higher median ISS of 9 (IQR 4-17), with a p-value of 0.003. Among patients with comorbidities, 37.0% had mild injuries (ISS ≤ 8), 37.0% had moderate injuries (ISS 9-15), 15.2% had severe injuries (ISS 16-24), and 10.8% had critical injuries (ISS ≥ 25). In contrast, patients without comorbidities showed a distribution of 37.3% with mild injuries, 31.7% with moderate injuries, 15.2% with severe injuries, and 15.8% with critical injuries with a p-value of < 0.001 for all comparisons. The most common injuries found in trauma patients were falls, MVCs and gunshot wounds. Falls accounted for 49.1% of cases in patients with positive comorbidities, whereas MVCs and gunshot wounds accounted for 19.6%, and 6.9% respectively. In contrast, among patients without previous comorbidities, falls were notably less common at 16.7%, while MVCs and gunshot wounds were more prevalent at 28.7% and 18.5% respectively with a p-value of < 0.001 for all comparisons.

For patients with comorbidities, 46.4% were admitted to the floor, 24.0% to the intensive care unit (ICU), 15.4% to the operating room, 2.9% were discharged home, 0.5% were sent to the morgue, and 10.7% to other destinations (e.g., AMA, correctional facility). Patients without comorbidities had the following distribution: 39.2% to the floor, 20.4% to the ICU, 28.2% to the operating room, 3.8% were discharged home, 2.8% were sent to the morgue, and 5.6% to other destinations with a p-value of < 0.001 for all comparisons. Refer to table {4}.

The overall fatality rate was 4.8%. Patients with comorbidities had a lower fatality rate of 3.8% compared to 7.2% for those without comorbidities, with a p-value of < 0.001. The median hospital LOS was 4 days (IQR 2-7) for all patients. Those with comorbidities had a median LOS of 4 days (IQR 2-8), while those without comorbidities had a median LOS of 3 days (IQR 1-6), with a p-value of < 0.001. Overall, 34.3% of patients were admitted to the ICU. Patients with comorbidities had a slightly higher ICU admission rate of 35.3% compared to 31.8% for those without comorbidities, with a p-value of 0.003. The median ICU stay was 3 days (IQR 2-5) for all patients. Patients with comorbidities had a median ICU stay of 3 days (IQR 2-5), while those without comorbidities had a median ICU stay of 2 days (IQR 2-5), with a non-significant p-value of 0.100. The overall ventilator use rate was 13.5%. Patients with comorbidities had a lower ventilator use rate of 12.0% compared to 17.3% for those without comorbidities, with a p-value of < 0.001. The median duration of ventilator use was 3 days (IQR 1-7) for all patients. Patients with comorbidities had a median ventilator use duration of 3 days (IQR 2-8), while those without comorbidities had a median duration of 2 days (IQR 1-7), with a p-value of 0.003. Refer to table {4}.

Table {4}: hospitalization course and outcome, stratified by previous medical comorbidity status (Unadjusted analysis).

Variables	**Total patients (N=8365)**	**Positive for Medical Comorbidity (N=5968,71.3%)**	**No Medical Comorbidity (N=2397,28.7%)**	**P-value**
Age(years) ± SD	50.9 ±21.1	55.8±20.5	38.7±17.1	<0.001
Injury Severity Score	9 (4-16)	9 (4-16)	9(4-17)	0.003
Injury Severity Score (%)				
- Mild ≤8	3099 (37.1%)	2205 (37.0%)	894 (37.3%)	
- Moderate 9-15	2956 (35.5%)	2207 (37.0%)	758 (31.7%)	<0.001
- Severe 16-24	1270 (15.2%)	907 (15.2%)	363 (15.2%)	
- Critical ≥ 25	1024 (12.3%)	645 (10.8%)	379 (15.8%)	
Mechanism of Injury (%)				
- Fall	3329 (39.8%)	2929 (49.1%)	400 (16.7%)	
- MVC	1859 (22.2%)	1171 (19.6%)	688 (28.7%)	
- Gunshot	858 (10.3%)	414 (6.9%)	444 (18.5%)	
- Stab wound	306 (3.7%)	190 (3.2%)	116 (4.8%)	<0.001
- Assault	404 (4.8%)	307 (5.1%)	97 (4.0%)	
- Motorcycle	423 (5.1%)	242 (4.1%)	181 (7.6%)	
- Pedestrian	382 (4.6%)	278 (4.7%)	104 (4.3%)	
- Others	804 (9.6%)	437 (7.3%)	367 (15.3%)	
Post ED Disposition (%)				
- Floor	3712 (44.4%)	2772 (46.4%)	940 (39.2%)	
- Intensive care unit	1921 (23.0%)	1433 (24.0%)	488(20.4%)	
- Operating room	1598 (19.1%)	921 (15.4%)	677 (28.2%)	<0.001
- Home	263 (3.1%)	173 (2.9%)	90 (3.8%)	
- Morgue	99 (1.2%)	31 (0.5%)	68 (2.8%)	

- Others (AMA, Correctional Facility)	772 (9.2%)	638 (10.7%)	134 (5.6%)	
Fatality Rate (%)	398 (4.8%)	226 (3.8%)	172 (7.2%)	<0.001
Hospital Length of Stay (days, IQR)	4 (2-7)	4(2-8)	3(1-6)	<0.001
ICU Admission (%)	2864 (34.3%)	2104 (35.3%)	760 (31.8%)	0.003
ICU Stay Duration (days, IQR)	3 (2-5)	3 (2-5)	2 (2-5)	0.100
Ventilator Use (%)	1130 (13.5%)	718 (12.0%)	412 (17.3%)	<0.001
Ventilator Use Duration (days, IQR)	3 (1-7)	3 (2-8)	2 (1-7)	0.003

Medical comorbidities and trauma outcomes

The effect of presence of any medical comorbidities regardless of its type on trauma outcomes, adjusted for confounders, was analyzed. Patients with positive medical comorbidities had a significantly longer hospital length of stay, with an increase of 1.42 days (95% CI: +0.92 to +1.93) compared to those without comorbidities (p<0.001). The duration of ICU stay was also significantly longer for patients with comorbidities, showing an increase of 0.27 days (95% CI: +0.07 to +0.45) (p=0.005). There was no significant difference in ventilator use duration between patients with and without comorbidities, (95% CI: -0.26 to +0.17) (p=0.692). Patients with comorbidities had higher odds of ICU admission, with an odds ratio of 1.35 (95% CI: 1.19-1.55) (p<0.001). However, the odds of ventilator use did not differ significantly between patients with and without comorbidities, with an odds ratio of 0.88 (95% CI: 0.74-1.04) (p=0.143). Refer to table {5}.

Table {5}: medical comorbidities effect on trauma outcomes (adjusted analysis).

Trauma Outcome	**Positive Medical Comorbidities***		**Trauma Outcome**	**Positive Medical Comorbidities***	
	Change in Time (95% CI)	P-Value		Odds Ratio (95% CI)	P-Value
Hospital Length of Stay	+1.42 days (+0.92 - +1.93)	<0.001	Positive ICU admission status	1.35 (1.19-1.55)	<0.001
ICU Stay Duration	+0.27 days (+0.07 - +0.45)	0.005	Positive use of ventilator	0.88 (0.74-1.04)	0.143
Ventilator Use Duration	-0.04 days (-0.26 - +0.17)	0.692			

*Comparison group is patients without medical comorbidities.

Patients with cardiovascular disease had an increase of +3.13 days (95% CI: +1.90 to +4.37) in their hospital LOS compared to those without comorbidities ($p < 0.001$). Patients with cardiovascular disease had 2.04 (95% CI: 1.52-2.74) times higher odds (100% increase) of ICU admission compared to those without comorbidities ($p < 0.001$). There was a significant increase in ICU stay duration among patients with cardiovascular disease, with an additional +0.70 days (95% CI: +0.19 to +1.22, $p = 0.007$). However, the odds ratio for positive ventilator use among patients with cardiovascular disease was 0.92 (95% CI: 0.61-1.39, $p = 0.713$), indicating no significant association. Refer to table {6}.

Table {6}: Cardiovascular disease effect on trauma outcomes (adjusted analysis).

Trauma Outcome	**Positive cardiovascular disease***		**Trauma Outcome**	**Positive cardiovascular disease***	
	Change in Time (95% CI)	P-Value		Odds Ratio (95% CI)	P-Value
Hospital Length of Stay	+3.13 days (+1.90 - +4.37)	<0.001	Positive ICU admission status	2.04 (1.52-2.74)	<0.001
ICU Stay Duration	+0.70 days (+0.19 - +1.22)	0.007	Positive use of ventilator	0.92 (0.61-1.39)	0.713
Ventilator Use Duration	+0.10 days (-0.60 - +0.82)	0.769			

*Comparison group is patients without medical comorbidities.

Patients with respiratory disease had an increase of +2.64 days (95% CI: +1.61 to +3.66) in their hospital LOS compared to those without comorbidities ($p < 0.001$). Patients with respiratory disease had 1.87 (95% CI: 1.42-2.46) times higher odds (87% increase) of ICU admission compared to those without comorbidities ($p < 0.001$). There was a significant increase in ICU stay duration among patients with respiratory disease, with an additional +0.63 days (95% CI: +0.17 to +1.09, $p = 0.007$). However, the odds ratio for positive ventilator use among patients with respiratory disease was 0.80 (95% CI: 0.54-1.19, $p = 0.280$), indicating no significant association. Refer to table {7}.

Table {7}: Respiratory disease effect on trauma outcomes (adjusted analysis).

Trauma Outcome	Positive respiratory disease*		Trauma Outcome	Positive respiratory disease*	
	Change in Time (95% CI)	P-Value		Odds Ratio (95% CI)	P-Value
Hospital Length of Stay	+2.64 days (+1.61 - +3.66)	<0.001	Positive ICU admission status	1.87 (1.42-2.46)	<0.001
ICU Stay Duration	+0.63 days (+0.17 - +1.09)	0.007	Positive use of ventilator	0.80 (0.54-1.19)	0.280
Ventilator Use Duration	+0.19 days (-0.45 - +0.84)	0.555			

*Comparison group is patients without medical comorbidities.

Patients with combined cardiovascular and respiratory disease showed a non-significant increase of +1.69 days (95% CI: -0.06 to +3.44, p = 0.059) in their hospital LOS compared to those without comorbidities. The same patient group had 2.61(95% CI: 1.68-4.05) higher odds (160% increase) of ICU admission compared to those without comorbidities (p < 0.001). There was a significant increase in ICU stay duration among patients with combined cardiovascular and respiratory disease, with an additional +0.95 days (95% CI: +0.14 to +1.76, p = 0.033). However, the odds ratio for positive ventilator use among patients with combined cardiovascular and respiratory disease was 1.09 (95% CI: 0.57-2.08, p = 0.790), indicating no significant association. Refer to table {8}

Table {8}: Combined cardiovascular and respiratory disease effect on trauma outcomes (adjusted analysis).

Trauma Outcome	Positive cardiovascular and respiratory disease*		Trauma Outcome	Positive cardiovascular and respiratory disease*	
	Change in Time (95% CI)	P-Value		Odds Ratio (95% CI)	P-Value
Hospital Length of Stay	+1.69 days (-0.06 - +3.44)	0.059	Positive ICU admission status	2.61 (1.68-4.05)	<0.001
ICU Stay Duration	+0.95 days (+0.14 - +1.76)	0.033	Positive use of ventilator	1.09 (0.57-2.08)	0.790
Ventilator Use Duration	+0.22 days (-0.94 - +1.40)	0.703			

*Comparison group is patients without medical comorbidities.

Patients with neurological disease had a significant increase of +2.72 days (95% CI: +1.81 to +3.63, $p < 0.001$) in their hospital LOS compared to those without comorbidities. They also had 1.74 (95% CI: 1.37-2.20) times higher odds (74% increase) of ICU admission compared to those without comorbidities ($p < 0.001$). There was a significant increase in ICU stay duration among patients with neurological disease, with an additional +0.54 days (95% CI: +0.15 to +0.92, $p = 0.006$). However, the odds ratio for positive ventilator use among patients with neurological disease was 0.93 (95% CI: 0.67-1.30, $p = 0.705$), indicating no significant association. Refer to table {9}.

Table {9}: Neurological disease effect on trauma outcomes (adjusted analysis).

Trauma Outcome	**Positive neurological disease***		**Trauma Outcome**	**Positive neurological disease***	
	Change in Time (95% CI)	P-Value		Odds Ratio (95% CI)	P-Value
Hospital Length of Stay	+2.72 days (+1.81 - +3.63)	<0.001	Positive ICU admission status	1.74 (1.37-2.20)	<0.001
ICU Stay Duration	+0.54 days (+0.15 - +0.92)	0.006	Positive use of ventilator	0.93 (0.67-1.30)	0.705
Ventilator Use Duration	+0.16 days (-0.36 - +0.69)	0.546			

*Comparison group is patients without medical comorbidities.

Patients with mental and personality disorders had a significant increase of +2.48 days (95% CI: +1.84 to +3.12, $p < 0.001$) in their hospital LOS compared to those without comorbidities. They also had 1.59 (95% CI: 1.36-1.88) times higher odds (59% increase) of ICU admission compared to those without comorbidities ($p < 0.001$). Additionally, there was a significant increase in ICU stay duration among patients with mental and personality disorders, with an additional +0.48 days (95% CI: +0.21 to +0.74, $p < 0.001$). However, the odds ratio for positive ventilator use among patients with mental and personality disorders was 1.07 (95% CI: 0.86-1.33, $p = 0.501$), indicating no significant association. Refer to table {10}.

Table {10}: Mental and personality disorders including ADHD effect on trauma outcomes (adjusted analysis).

Trauma Outcome	**Positive mental and personality disorders***		**Trauma Outcome**	**Positive mental and personality disorders***	
	Change in Time (95% CI)	P-Value		Odds Ratio (95% CI)	P-Value
Hospital Length of Stay	+2.48 days (+1.84 - +3.12)	<0.001	Positive ICU admission status	1.59 (1.36-1.88)	<0.001
ICU Stay Duration	+0.48 days (+0.21 - +0.74)	<0.001	Positive use of ventilator	1.07 (0.86-1.33)	0.501
Ventilator Use Duration	+0.07 days (-0.26 - +0.41)	0.677			

*Comparison group is patients without medical comorbidities.

Patients with substance and drug use disorders had a significant increase of +2.87 days (95% CI: +2.11 to +3.62, $p < 0.001$) in their hospital LOS compared to those without comorbidities. They also had 2.27(95% CI: 1.90-2.72) times higher odds (127% increase) of ICU admission ($p < 0.001$). Furthermore, there was a significant increase in ICU stay duration among patients with substance and drug use disorders, with an additional +0.76 days (95% CI: +0.44 to +1.07, $p < 0.001$). Interestingly, patients with substance and drug use disorders had a higher odds ratio of positive ventilator use, with an odds ratio of 1.35 (95% CI: 1.07-1.70, $p = 0.010$) (35% increase). However, the duration of ventilator use when indicated did not significantly differ between patients with substance and drug use disorders and those without those comorbidities (change of +0.17 days, 95% CI: -0.24 to +0.58, $p = 0.410$). Refer to table {11}.

Table {11}: Substance and drug use disorders including alcohol effect on trauma outcomes (adjusted analysis).

Trauma Outcome	**Positive substance and drug use disorders***		**Trauma Outcome**	**Positive substance and drug use disorders***	
	Change in Time (95% CI)	P-Value		Odds Ratio (95% CI)	P-Value
Hospital Length of Stay	+2.87 days (+2.11 - +3.62)	<0.001	Positive ICU admission status	2.27 (1.90-2.72)	<0.001
ICU Stay Duration	+0.76 days (+0.44 - +1.07)	<0.001	Positive use of ventilator	1.35 (1.07-1.70)	0.010

Ventilator Use Duration	+0.17 days (-0.24 - +0.58)	0.410			

*Comparison group is patients without medical comorbidities.

Patients with bleeding disorders had a significant increase of +2.15 days (95% CI: +1.10 to +3.21, $p < 0.001$) in hospital length of stay compared to those without medical comorbidities. They also had 2.30 (95% CI: 1.78-2.98) times higher odds (130% increase) of ICU admission ($p < 0.001$). In addition, there was a significant increase in ICU stay duration among patients with bleeding disorders, with an additional +0.52 days (95% CI: +0.08 to +0.96, $p = 0.019$). However, patients with bleeding disorders did not show any significant difference in the odds of positive ventilator use compared to those without comorbidities, with an odds ratio of 0.86 (95% CI: 0.60-1.23, $p = 0.413$). Refer to table {12}.

Table {12}: Bleeding disorders including the use of anticoagulants effect on trauma outcomes (adjusted analysis).

Trauma Outcome	**Positive bleeding disorders***		**Trauma Outcome**	**Positive bleeding disorders***	
	Change in Time (95% CI)	P-Value		Odds Ratio (95% CI)	P-Value
Hospital Length of Stay	+2.15 days (+1.10 - +3.21)	<0.001	Positive ICU admission status	2.30 (1.78-2.98)	<0.001
ICU Stay Duration	+0.52 days (+0.08 - +0.96)	0.019	Positive use of ventilator	0.86 (0.60-1.23)	0.413
Ventilator Use Duration	-0.05 days (-0.65 - +0.54)	0.862			

*Comparison group is patients without medical comorbidities.

Cardiovascular risk factors and trauma outcomes

Patients with hypertension had a significant increase of +2.60 days (95% CI: +1.88 to +3.31, $p < 0.001$) in hospital length of stay compared to those without comorbidities. Also, they had 1.67 (95% CI: 1.40-2.00) times higher odds (67% increase) of ICU admission ($p < 0.001$). Additionally, there was a statistically significant increase in ICU stay duration among patients with hypertension, with an additional +0.67 days (95% CI: +0.40 to +0.95, $p < 0.001$). However, patients with hypertension did not show a significant difference in the odds of positive ventilator use compared to those without comorbidities, with an odds ratio of 0.93 (95% CI: 0.73-1.18, $p = 0.569$). Refer to table {13}.

Table {13}: Hypertension effect on trauma outcomes (adjusted analysis).

Trauma Outcome	**Positive Hypertension***		**Trauma Outcome**	**Positive Hypertension***	
	Change in Time (95% CI)	P-Value		Odds Ratio (95% CI)	P-Value
Hospital Length of Stay	+2.60 days (+1.88 - +3.31)	<0.001	Positive ICU admission status	1.67 (1.40-2.00)	<0.001
ICU Stay Duration	+0.67 days (+0.40 - +0.95)	<0.001	Positive use of ventilator	0.93 (0.73-1.18)	0.569
Ventilator Use Duration	+0.25 days (-0.08 - +0.58)	0.140			

*Comparison group is patients without medical comorbidities.

Patients with diabetes mellitus had a significant increase of +2.72 days (95% CI: +1.84 to +3.60, p < 0.001) in their hospital length of stay compared to those without comorbidities. Additionally, they had 1.66 (95% CI: 1.33-2.06) times higher odds (66% increase) of ICU admission (p < 0.001).Moreover, there was a significant increase in ICU stay duration among patients with diabetes mellitus, with an additional +0.60 days (95% CI: +0.24 to +0.95, p < 0.001).However, patients with diabetes mellitus did not show a significant difference in the odds of positive ventilator use compared to those without comorbidities, with an odds ratio of 0.86 (95% CI: 0.64-1.15, p = 0.317). Refer to table {14}.

Table {14}: Diabetes Mellitus effect on trauma outcomes (adjusted analysis).

Trauma Outcome	**Positive Diabetes Mellitus***		**Trauma Outcome**	**Positive Diabetes Mellitus***	
	Change in Time (95% CI)	P-Value		Odds Ratio (95% CI)	P-Value
Hospital Length of Stay	+2.72 days (+1.84 - +3.60)	<0.001	Positive ICU admission status	1.66 (1.33-2.06)	<0.001
ICU Stay Duration	+0.60 days (+0.24 - +0.95)	<0.001	Positive use of ventilator	0.86 (0.64-1.15)	0.317
Ventilator Use Duration	+0.25 days (-0.21 - +0.72)	0.289			

*Comparison group is patients without medical comorbidities.

Patients with obesity had a significant increase of +4.36 days (95% CI: +3.39 to +5.34, $p < 0.001$) in their hospital length of stay compared to those without comorbidities. Also, they had 1.78 (95% CI: 1.39-2.27) times higher odds (78% increase) of ICU admission ($p < 0.001$). Furthermore, there was a significant increase in ICU stay duration among patients with obesity, with an additional +1.43 days (95% CI: +0.97 to +1.88, $p < 0.001$). Although, patients with obesity did not show a significant difference in the odds of positive ventilator use compared to those without comorbidities, with an odds ratio of 1.25 (95% CI: 0.89-1.75, $p = 0.182$), the duration of ventilator use did show a significant increase among patients with obesity, with an additional +0.79 days (95% CI: +0.18 to +1.41, $p = 0.011$). Refer to table {15}.

Table {15}: Obesity effect on trauma outcomes (adjusted analysis).

Trauma Outcome	**Positive Obesity***		**Trauma Outcome**	**Positive Obesity***	
	Change in Time (95% CI)	P-Value		Odds Ratio (95% CI)	P-Value
Hospital Length of Stay	+4.36 days (+3.39 - +5.34)	<0.001	Positive ICU admission status	1.78 (1.39-2.27)	<0.001
ICU Stay Duration	+1.43 days (+0.97 - +1.88)	<0.001	Positive use of ventilator	1.25 (0.89-1.75)	0.182
Ventilator Use Duration	+0.79 days (+0.18 - +1.41)	0.011			

*Comparison group is patients without medical comorbidities.

Patients who were current smokers had a significant increase of +1.06 days (95% CI: +0.54 to +1.50, $p < 0.001$) in their hospital length of stay compared to those without comorbidities. Additionally, patients who were current smokers had 1.17 (95% CI: 1.01-1.36) times higher odds (17% increase) of ICU admission ($p = 0.029$). However, there was no statistically significant difference in ICU stay duration among patients who were current smokers, with an increase of +0.18 days (95% CI: -0.04 to +0.41, $p = 0.117$). Interestingly, patients who were current smokers had significantly lower odds of ventilator use compared to those without comorbidities, with an odds ratio of 0.71 (95% CI: 0.58-0.87, $p < 0.001$). However, the duration of ventilator use did not show any significant difference among patients who were current smokers, with a change of -0.10 days (95% CI: -0.39 to +0.17, $p = 0.460$). Refer to table {16}.

Table {16}: current smoking effect on trauma outcomes (adjusted analysis).

Trauma Outcome	**Positive current smoker***		**Trauma Outcome**	**Positive current smoker***	
	Change in Time (95% CI)	P-Value		Odds Ratio (95% CI)	P-Value
Hospital Length of Stay	+1.06 days (+0.54 - +1.50)	<0.001	Positive ICU admission status	1.17 (1.01-1.36)	0.029
ICU Stay Duration	+0.18 days (-0.04 - +0.41)	0.117	Positive use of ventilator	0.71 (0.58-0.87)	<0.001
Ventilator Use Duration	-0.10 days (-0.39 - +0.17)	0.460			

*Comparison group is patients without medical comorbidities.

Looking into compounded cardiovascular risk factors effect on trauma outcomes, we found that patients with one cardiovascular disease (CVD) risk factor, the hospital length of stay increased by 0.39 days (95% CI: -0.08 to +0.88). However, the difference was not statistically significant. For those with two CVD risk factors, the increase was significant at 1.98 days (95% CI: +1.31 to +2.64). Those with three CVD risk factors had a significant increase in hospital length of stay of 3.00 days (95% CI: +1.78 to +4.23, $p < 0.001$). Interestingly, for those with four CVD risk factors, the increase was 2.86 days, though this result was not statistically significant (95% CI: -1.16 to +6.90). Refer to table {17}.

In terms of ICU stay duration, those with one CVD risk factor had a negligible change of +0.01 days (95% CI: -0.16 to +0.19). With two CVD risk factors, the ICU stay significantly increased by 0.45 days (95% CI: +0.20 to +0.70). Patients with three CVD risk factors experienced a significant increase of 1.11 days (95% CI: +0.65 to +1.57), and those with four risk factors had a significant increase of 2.52 days (95% CI: +1.00 to +4.04). Refer to table {17}.

Regarding ventilator use duration, the duration decreased by 0.17 days for those with one CVD risk factor (95% CI: -0.38 to +0.03) which was not statistically significant. For those with two risk factors, there was a significant increase of 0.19 days (95% CI: -0.09 to +0.47). Patients with three risk factors had an even higher significant increase of 0.57 days (95% CI: +0.05 to +1.10). Those with four risk factors saw an increase of 1.02 days, but it was not statistically significant (95% CI: -0.71 to +2.76). Refer to table {17}.

For ICU admission status, patients with one CVD risk factor had an odds ratio of 1.05 (95% CI: 0.93 to 1.19), indicating a slight but not significant increase. With two CVD risk factors, the odds ratio was significant at 1.20 (95% CI: 1.02 to 1.42). For those with three CVD risk factors, the odds ratio was even higher and significant at 1.65 (95% CI: 1.23 to 2.19). Patients with four

CVD risk factors had a markedly increased and significant odds ratio of 2.72 (95% CI: 1.08 to 6.83). Refer to table {17}.

As for the use of ventilators, patients with one CVD risk factor had a reduced significant odds ratio of 0.68 (95% CI: 0.57 to 0.81). Those with two CVD risk factors had an odds ratio of 0.85 (95% CI: 0.67 to 1.08), indicating a non-significant change. For patients with three CVD risk factors, the odds ratio was higher at 1.06 (95% CI: 0.70 to 1.59) showing no significant change. Those with four risk factors had a higher but non-significant odds ratio of 2.64 (95% CI: 0.89 to 7.84). Refer to table {17}.

Table {17}: compounded cardiovascular risk factors effect on trauma outcomes (adjusted analysis).

Trauma outcomes	**One CVD Risk Factor***	**Two CVD Risk Factors***	**Three CVD Risk Factors***	**Four CVD Risk Factors***
	Change in Time (95% CI)			
Hospital Length of Stay (days)	+0.39 (-0.08 -+0.88)	+1.98(+1.31-2.64)	+3.00(+1.78-4.23)	+2.86(-1.16 - +6.90)
ICU Stay Duration (days)	+0.01 (- 0.16 -+0.19)	+0.45(+0.20-+0.70)	+1.11(+0.65-+1.57)	+2.52(+1.00 -+4.04)
Ventilator Use Duration (days)	- 0.17 (- 0.38 - +0.03)	+0.19(-0.09 -+0.47)	+0.57(+0.05-+1.10)	+1.02(-0.71-+2.76)
	Odds Ratio (95% CI)			
Positive ICU admission status	1.05 (0.93-1.19)	1.20(1.02-1.42)	1.65(1.23-2.19)	2.72(1.08-6.83)
Positive use of ventilator	0.68 (0.57-0.81)	0.85(0.67-1.08)	1.06(0.70-1.59	2.64(0.89-7.84)

*Comparison group is patients without medical comorbidities.

Discussion

General summary

Our study examined the effect of various medical comorbidities and cardiovascular risk factors on trauma outcomes (hospital length of stay, ICU admission and duration, ventilator use, and ventilator use duration). The presence of medical comorbidities significantly increased the hospital length of stay. Interestingly, patients with obesity had the longest stay, averaging an additional 4.36 days followed by cardiovascular disease (+3.13 days), substance and drug use disorders (+2.87 days), neurological disease (+2.72 days), diabetes mellitus (+2.72 days), respiratory disease (+2.64 days), hypertension (+2.60 days), mental and personality disorders (+2.48 days), bleeding disorders (+2.15 days), and current smokers (+1.06 days). Refer to figure {1}.

Additionally, patients with medical comorbidities showed higher odds of ICU admission. The highest odds of increase was seen in patients with combined cardiovascular and respiratory diseases (OR: 2.61) followed by bleeding disorders (OR: 2.30), substance and drug use disorders (OR: 2.27), cardiovascular disease (OR: 2.04), respiratory disease (OR: 1.87), neurological disease (OR: 1.74), hypertension (OR: 1.67), diabetes mellitus (OR: 1.66), mental and personality disorders (OR: 1.59), and current smokers (OR: 1.17). ICU stay duration was longer for patients with medical comorbidities with obesity again having the most significant effect, increasing ICU stay by 1.43 days followed by substance and drug use disorders (+0.76 days), cardiovascular disease (+0.70 days), hypertension (+0.67 days), respiratory disease (+0.63 days), diabetes mellitus (+0.60 days), neurological disease (+0.54 days), bleeding disorders (+0.52 days), and mental and personality disorders (+0.48 days). Refer to figure {2}.

Regarding ventilator use, the results were less consistent, the odds of ventilator use were higher only in patients with substance and drug use disorders (OR: 1.35). While other conditions showed varied odds, they were not statistically significant. Additionally, the duration of ventilator use was not significantly prolonged for most conditions. The only significant increase was seen in patients with obesity (+0.79 days).

<u>Figure {1}:</u>

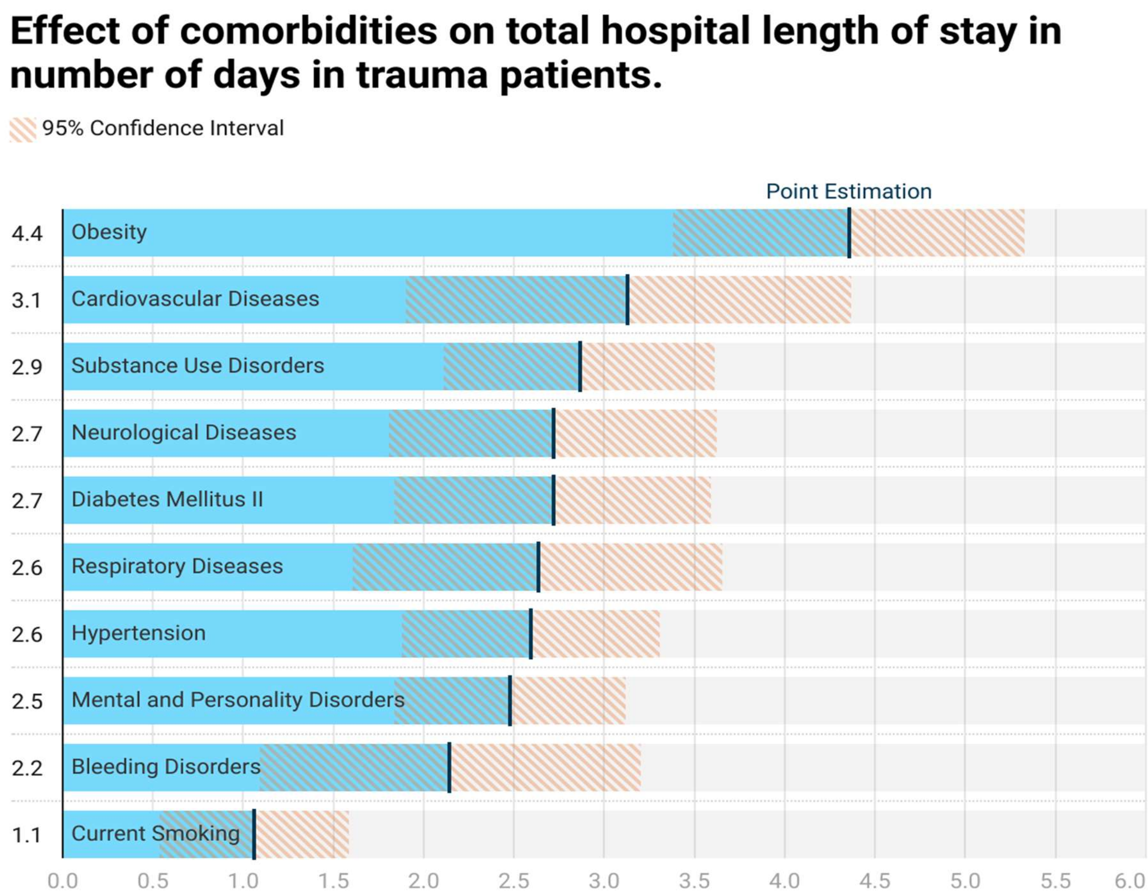
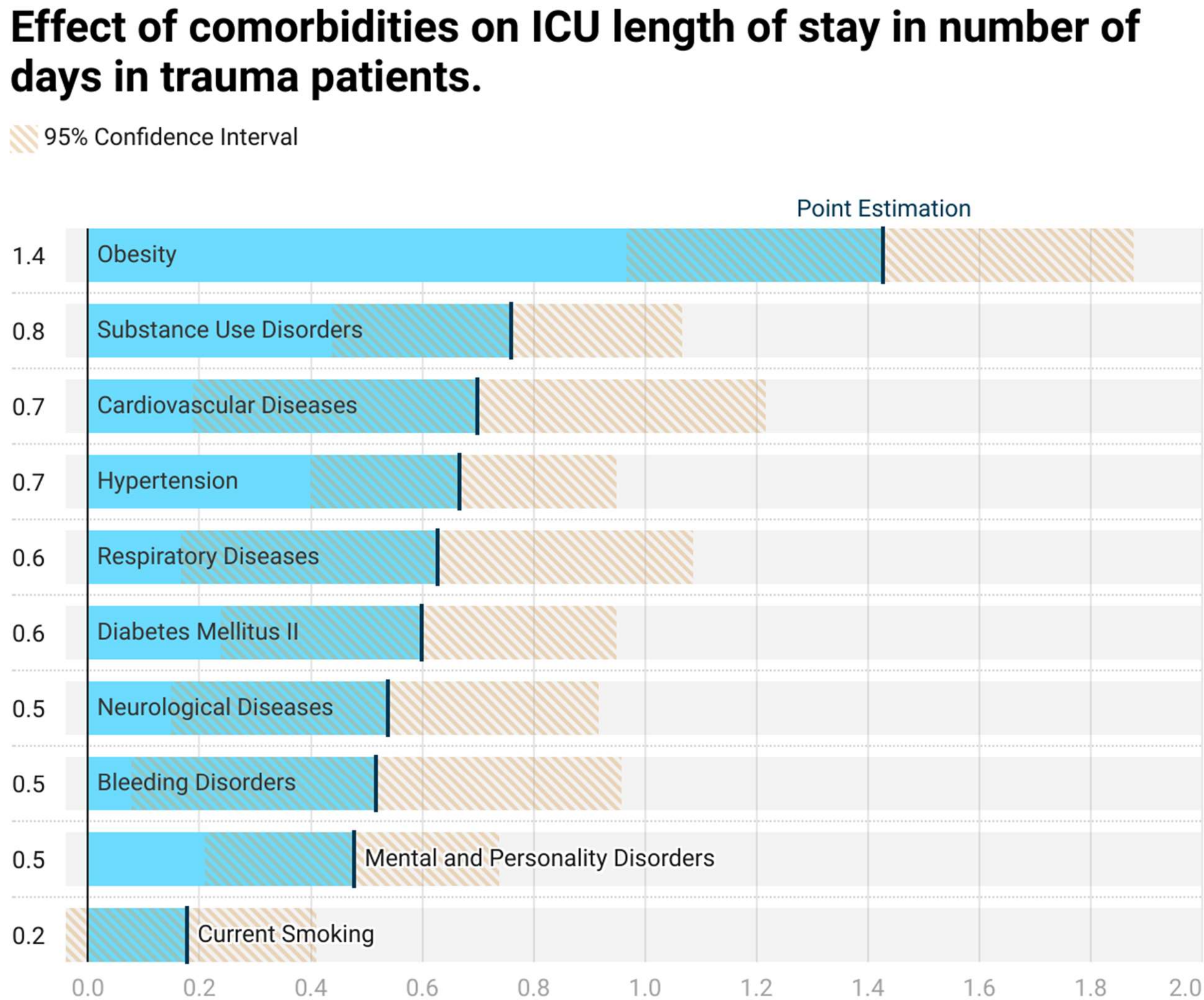


Figure {2}:



Demographic effects on injury patterns and hospitalization outcomes

The predominance of males (64.6%) over females in our trauma dataset is consistent with existing literature, which identifies males as being more frequently involved in high-risk activities. This finding aligns with a decade-long study conducted in 2007 showing that 75% of trauma patients were males (26). The mean age of the patients in our study was 50.9 years, which is slightly lower than a large epidemiological study conducted in the US on 21 million trauma patients, where the average age was reported to be 59 years (5). This difference may be attributed to the fact that Milwaukee County having a slightly lower average age compared to the national average in the US (19). However, a significant age disparity was noted, with a gap of 10 years between males and females (47.1 vs. 57.8 years). Both the gender and age differences affected injury patterns, medical comorbidity profiles, and trauma outcomes. For example, falls were the most common cause of injury overall, representing 39.8% of cases, with a significantly higher prevalence in females (54.5%) compared to males (31.7%). The literature supports that females are more susceptible to falls, although their outcomes might not differ significantly from their male counterparts (27). These findings suggest that it might be helpful to establish community programs for fall prevention, particularly targeting elderly females.

Motor vehicle collisions (MVCs) were the second most common injury mechanism at 22.2%, followed by gunshot wounds at 10.3%. Notably, males showed a higher prevalence of gunshot wounds (13.9%) compared to females (3.6%). This gender disparity might reflect different risk behaviors between genders and possibly socioeconomic factors affecting violent trauma in Milwaukee County. In addition, males showed a higher median ISS of 9 (IQR 4-17) compared to females with an ISS of 9 (IQR 4-13). This difference is due to the higher prevalence of high-risk injuries, such as gunshot wounds and motorcycle accidents sustained in males whereas females more commonly sustained injuries from falls, which typically result in less severe injuries. For instance, falls in our study primarily resulted in mild (36.6%) or moderate (40.3%) injuries, with fewer patients experiencing severe (14.1%) or critical (9.0%) injuries. In contrast, gunshot wounds had higher rates of severe (16.2%) and critical (18.9%) injuries.

The median hospital length of stay for the total population in our study was 4 days (range 2-7). These findings are shorter than those of a large multicenter study conducted on 313,000 trauma cases in the US, which reported a mean LOS of 9.6 days (28). This is likely due to the inclusion of all types of traumas, including mild and moderate cases in our study, whereas the US study included only major trauma cases. Additionally, males had a shorter median hospital length of stay at 3 days (1-7) compared to females at 4 days (2-7). This difference can be attributed to higher early mortality rates among males, likely due to the severity of their injuries, which is reflected in the percentage of patients transported to the morgue directly from the emergency department (1.6% in males vs. 0.5% in females). It is also important to emphasize that females in our study were on average ten years older and often have more comorbidities which tend to prolong hospital stays.

ICU admission was required for 34.3% of the total patients in our study. These findings are comparable to a multicenter study in the US, which showed a prevalence of 33.8% (29). Additionally, ICU admission was required for 37.1% of males compared to 29.2% of females and males had a longer median ICU stay of 3 days, compared to 2 days for females (both survivors and non survivors included). Again, this difference is likely due to the more severe injury profile sustained by males, which resulted in a higher percentage of patients getting admitted to ICU and a longer ICU stay. For the same reason, males also showed a higher prevalence of ventilator use at 15.9% compared to 9.3% for females, with a higher median ventilator use of 3 days (range 2-8) compared to 2 days (range 1-6) for females.

Overall, 71.3% of the total patient population had at least one preexisting medical comorbidity in our study. Our results are slightly higher than the national US average published by the CDC in 2018, which reported that 51.8% of US adults had at least one preexisting chronic condition(30). This discrepancy could be due to the generally worse health state of trauma patients, influenced by their socioeconomic backgrounds, which were unfortunately not included and not controlled for in our study. Furthermore, a significantly higher prevalence of comorbidities was observed in females (78.4%) compared to males (67.5%), possibly due to the ten-year age difference between the two cohorts. Females showed a higher prevalence of all medical comorbidity categories (cardiovascular diseases, respiratory diseases, neurological diseases, mental and personality disorders, and bleeding disorders) except for substance use disorders, where males had a higher prevalence. This finding is consistent with the literature on substance use disorders (31).

Following the same trend, and due to the age differences between the two cohorts, cardiovascular risk factors, including hypertension, diabetes mellitus, and obesity, showed higher prevalence in females. In contrast, smoking had a higher prevalence in males, consistent with literature showing higher smoking prevalence in males (32). The fatality rate in our study was 4.8%, comparable to a US multicenter epidemiological study rate of 4.7% (18). However, males had a higher fatality rate (5.3%) compared to females (3.7%) despite being younger, likely due to the more severe injury profile sustained by males. These results are consistent with a recent systematic review which found that male trauma patients have 1.4 times the odds of mortality compared to females(7).

Medical comorbidities and injury types

Out of the total population, 37.1% had a mild injury, 35.5% had a moderate injury, 15.2% had a severe injury, and 12.3% had a critical injury, as classified based on ISS. Our results are comparable to a multicenter epidemiological study conducted in 2011, which showed that the prevalence of severe and critical injuries combined was 28% of the total trauma population (5). However, patients with medical comorbidities showed a slightly lower median Injury Severity Score of 9 (IQR 4-16) compared to 9 (IQR 4-17) in those without comorbidities. This indicates that on average, patients with comorbidities tended to have slightly less severe injuries than those without such conditions. The lower ISS among patients with comorbidities can be explained by the higher prevalence of falls within this group, which accounted for 49.1% of cases. Falls, while common in both groups, were notably less common among patients without comorbidities, comprising only 16.7% of cases in that subgroup. In contrast, MVCs and gunshot wounds, which typically cause more severe injuries, were more prevalent among patients without comorbidities (28.7% and 18.5%, respectively) compared to those with comorbidities (19.6% and 6.9%, respectively). Following the same trend, and likely due to the different injury types and ISS, patients with comorbidities had a lower fatality rate of 3.8% compared to 7.2% for those without comorbidities.

Medical comorbidities effect on hospital length of stay

The median hospital length of stay (LOS) for all patients was 4 days (2-7) in our study, which is comparable to a study conducted in Michigan, US, on 400,000 trauma patients, where the hospital LOS was also 4 days (IQR 2-7) (33). However, patients with preexisting comorbidities, in both crude and adjusted analyses, had a longer hospital length of stay by an average of 1.42 days. Our findings align with a study conducted by Bergeron et al., which showed that patients under 55 years old with comorbidities had an additional 3.6 days in hospital length of stay, even with similar Injury Severity Scores (34). Another study by Mackenzie et al. found that the mean length of stay was 69% higher for patients with comorbidities compared to those without (35).

In stratified analysis, patients with obesity had the longest stay, averaging an additional 4.36 days, followed by cardiovascular disease (+3.13 days), substance and drug use disorders (+2.87 days), neurological disease (+2.72 days), diabetes mellitus (+2.72 days), respiratory disease (+2.64 days), hypertension (+2.60 days), mental and personality disorders (+2.48 days), bleeding disorders (+2.15 days), and current smokers (+1.06 days). Our results are comparable to a study conducted by Hong et al., which examined the effect of each single comorbidity on hospital LOS (36). Although Hong et al.'s findings are reported in terms of odds ratios (ORs) for prolonged hospital stay above the 75th percentile length of stay, their findings are comparable to our study. The 75th percentile of hospital LOS in our study is 7 days. Hong et al. showed that patients with conditions such as congestive heart failure, cardiac arrhythmias, and peripheral vascular disease were, on average, twice as likely to have a prolonged hospital stay, which is comparable to the increase of +3.13 days above the median hospital LOS of 4 days seen in patients with cardiovascular diseases in our study (36). Another study focused on cardiovascular diseases in trauma patients conducted in the US found that for a patient with congestive heart failure, the hospital stay increased by an average of +1.5 days, and for a patient with a pulmonary circulation disorder, the increase was +1.6 days (33). These findings further support the extended LOS observed in our study for patients with cardiovascular diseases which highlights the significant impact of cardiovascular diseases on hospital length of stay in trauma patients. These differences suggest that is important to perform a thorough risk assessment, and tailor management strategies for trauma patients with cardiovascular comorbidities. Effective management strategies could potentially include regular monitoring of volume status, optimization of pre-existing cardiovascular diseases, and early intervention for any complications arising during the hospital stay.

Regarding respiratory and neurological diseases, Hong et al. found that patients with chronic obstructive pulmonary disease (COPD) and all neurological diseases, except for Alzheimer's and paralysis, were approximately twice as likely to have a prolonged hospital stay (36). In our study, the effect was less pronounced, with an increase of +2.72 days for neurological diseases and +2.64 days for respiratory diseases above the median hospital length of stay (LOS) of 4 days. Additionally, Hong et al. found that patients with psychosis or depression were five times as likely to have prolonged hospital LOS, whereas in our study we noted a less pronounced increase at +2.48 days above the median hospital LOS of 4 days in patients with mental and personality disorders(36). This difference might be due to the lower percentage of patients with medical comorbidities in Hong et al.'s study, which was 12.24%, compared to 71.3% in our study. Another possibility is that the Hong study potentially included only terminal diseases with severe presentations, compared to our sample, which might have included patients with controlled diseases as well. For instance, the prevalence of hypertension in their sample was 5.4%, while in our study, it was 35.5%(36). Another study by Bergeron et al. found that the presence of neurological diseases or respiratory diseases was associated with an increase of 9 to 11 days above the average hospital length of stay (34). This increase found in Bergeron's study is significantly longer than in our study, where neurological diseases and respiratory diseases were associated with an increase of 2.72 days and 2.64 days, respectively. This variation likely stems from the diverse spectrum of conditions falling under these two categories, given the lack of specific information in these two papers on the exact diseases included.

Regarding substance and drug abuse disorders and bleeding diseases, the Hong study found that alcohol abuse increased the likelihood of prolonged hospital stay by 2.61 times, while in our study, substance and drug use disorders were associated with an increase of +2.87 days above the median hospital LOS of 4 days (36). Another study by Andelic et al., which primarily focused on substance use disorders, found an increase of 2 days in hospital length of stay, which was almost similar to the increase observed in our study (37). Additionally, Hong et al. did not find any significant association between bleeding disorders and hospital LOS, whereas our study found an increase of +2.15 days for patients with bleeding disorders (36). Given the diverse nature of these conditions, it would be beneficial for future research to study the effect of each disease of these categories separately.

Regarding cardiovascular risk factors, Hong's study found that hypertension and diabetes were associated with increased odds of prolonged hospital stay above the 75% percentile, with odds ratios of 1.67 and 1.74, respectively (36). Additionally, Yang et al. found that hypertension was associated with an increase of 10.6 hours in hospital LOS (33). In our study, however, hypertension and diabetes were associated with an increase in hospital length of stay by +2.60 days and +2.72 days, respectively, above the median hospital LOS of 4 days. This is a smaller effect than in the Hong study but bigger than the Yang study. These variations may be attributed to differences in the characteristics of the trauma population, different sample sizes, and different definitions of prolonged hospital stay. A study conducted by Brown et al. on blunt traumatic injuries found that patients with obesity spent five more days in the hospital on average compared to non-obese patients (38). Further supporting this evidence, a recent systematic review of over 900,000 obese trauma patients found that obesity was associated with a longer hospital length of stay, with a standardized mean difference of 0.23 in standard deviation units (39). In our study, we found that obesity increased hospital LOS by an additional 4.36 days, which corresponds to approximately a 0.42 standardized mean difference in SD. This difference is likely caused by the substantial difference in sample sizes, which allowed for a more precise estimation of the effect in the systematic review.

Looking into the effect of smoking on hospital length of stay in the literature, a large epidemiological study conducted in the US on approximately 630,278 critically injured trauma patients found that smokers had an average increase in hospital LOS of around 0.40 days (40). This is comparable to the observed change in our study, where smoking was associated with an increase of 1.06 days. However, another study by Resnick et al. found that smoking had no significant effect on hospital LOS (41). Given these mixed results, we would suggest the need for further research to clarify the impact of smoking on hospital LOS, possibly taking into account different trauma patient populations. This may include clarifying the effects of those with mild to moderate injuries, the varying definitions of positive smoking status, and smoking characteristics such as the duration of smoking and the number of packs consumed per day. Also, to the best of our knowledge, we did not find any relevant studies on the effect of compounded cardiovascular risk factors on hospital length of stay in trauma patients.

<u>Medical comorbidities effect on ICU admission and ventilator use</u>

Patients with medical comorbidities had higher odds of ICU admission, with an odds ratio of 1.35 in crude analysis. In stratified analysis, the highest odds of increase was seen in patients with combined cardiovascular and respiratory diseases (OR: 2.61) followed by bleeding disorders (OR: 2.30), substance and drug use disorders (OR: 2.27), cardiovascular disease (OR: 2.04), respiratory disease (OR: 1.87), neurological disease (OR: 1.74), hypertension (OR: 1.67), diabetes mellitus (OR: 1.66), mental and personality disorders (OR: 1.59), and current smokers (OR: 1.17). Furthermore, ICU stay duration was longer for patients with medical comorbidities with obesity having the most significant impact, increasing ICU stay by 1.43 days followed by substance and drug use disorders (+0.76 days), cardiovascular disease (+0.70 days), hypertension (+0.67 days), respiratory disease (+0.63 days), diabetes mellitus (+0.60 days), neurological disease (+0.54 days), bleeding disorders (+0.52 days), and mental and personality disorders (+0.48 days). However, the odds of ventilator use did not differ significantly between patients with and without comorbidities.

A study on burn patients in the US with cardiovascular comorbidity found that cardiovascular diseases increased the odds of ICU admission by 30%. It also increased ICU length of stay by 7.7 days and ventilator use duration by 5 days (42). These results can be compared to the findings in our study, although it should be noted that burn injuries generally cause what is known as "burn shock" (42). This complex condition leads to a profound, persistent, and unique derangement of cardiovascular function. While other injury types can cause hypovolemic shock, it is to a lesser extent. This may be why the increase was less pronounced in our study, with an ICU length of stay increase of 0.70 days and no significant effect on the duration of ventilator use. Another study by Tracy et al. evaluated the effect of metabolic syndrome, which can potentially include cardiovascular disease and cardiovascular risk factors, on ICU stay (43). They found that patients with metabolic syndrome had a longer ICU stay by 4 days (43). These findings altogether, although suggestive of a possible link, especially for burn patients, indicate that further research needs to be done. Future studies should focus on individual cardiovascular diseases to better understand their specific effect on ICU admission state.

Mental and personality disorders were associated with an OR of 1.59 for ICU admission in our study. This is comparable to a study conducted on approximately 20,000 trauma patients with psychiatric illness in the US, which found that psychiatric comorbidity was an independent predictor of intensive care unit admission with an OR of 1.32 (44). Another study by Meyer et al. found that that psychiatric comorbidities extended ICU stays by one day (45), which is close to our findings of an additional + 0.48 days. This indicates that patients with mental and personality disorders should be closely monitored for potential complications requiring intensive care admission and managed by multidisciplinary care teams.

Substance and drug use disorders were associated with an OR of 2.27 for ICU admission in our study. This is comparable to a study by Williams et al., which evaluated the effect of alcohol on ICU admission status and found that alcohol use was associated with an OR of 1.70 for ICU admission (46). They also found that ICU stay duration was prolonged by an additional 3.44 days compared to non-alcoholic patients(46). In our study, we observed an increase of an additional 0.76 days. The larger increase in their study could be due to the fact that they included only alcoholic patients, whereas we included all types of substance use, which might have introduced mixed effects and dampened the overall effect. The same study evaluated the difference in mechanical ventilation in alcoholic versus non-alcoholic patients and found that alcoholics were more likely to require mechanical ventilation, although their results were not statistically significant (46). However, in our study, we identified a significant increase in positive ventilator use in patients with substance use and drug disorders, with an OR of 1.35. This could be due to the fact that our study benefited from a larger sample size (8,365 patients) compared to Williams et al. (3,476 patients) which may have enabled us to estimate the effect size more precisely.

Bleeding disorders, including the use of anticoagulants, were associated with an increase of around +0.52 days in ICU stay in our study. These results are comparable to findings from a large systematic review and meta-analysis involving 35,925 patients, which reported a weak association between the use of anticoagulants and prolonged ICU stay, with a mean difference of

+0.62 days (95% CI −0.13 to 1.36) (47). However, their results were not statistically significant, and they noted a high level of heterogeneity across studies. In our study, we grouped together both anticoagulant use and inherited bleeding disorders due to our small sample size, which may have amplified our findings. Identifying patients with bleeding disorders early is crucial for close monitoring of potential complications that may necessitate ICU admission.

Regarding the effect of cardiovascular risk factors on ICU admission status and ventilator use, we found that hypertension was associated with an odds ratio of 1.67 for ICU admission. These results are comparable to those of a study by Portelli Tremont et al., which reported hypertension as being associated with an odds ratio of 1.28 for ICU admission in trauma patients (48). Furthermore, in our study, diabetes mellitus was associated with an OR of 1.66 for ICU admission and an additional + 0.60 days spent in the ICU compared to non-diabetics. These results are consistent with a large epidemiological study on patients with diabetes in the US, which showed that patients with diabetes were more likely to require ICU admission (38.4% in the DM group vs 35.9% in the non-DM group) (49). That same study found that diabetes was associated with a longer ICU stay of around 1.5 days, similar to our findings. In that study, diabetes was not associated with increased odds of ventilator use, similar to our findings. However, the ventilator use duration was longer for the diabetes group, with an increase of around 2.4 days(49). In our study, we were unable to identify any significant association of diabetes with ventilator use and duration, possibly due to our smaller sample size compared to their study.

A recent systematic review on obesity found that obesity was associated with a longer ICU stay, with a standardized mean difference of 0.19 in standard deviation units (39). In our study, we found that obesity increased ICU stay by an additional 1.43 days, which corresponds to approximately a 0.23 standardized mean difference in SD. Similarly, a study by Brown et al. on blunt traumatic injuries reported that patients with obesity had one additional day of ICU stay and 2 more days of mechanical ventilation on average (38), which is comparable to our findings of 1.43 additional days in ICU and +0.79 additional days on ventilator use. Another meta-analysis also confirmed that obese trauma patients experience longer stays in the intensive care unit (50). Moreover, a retrospective study conducted in the US found that morbidly obese patients had a higher number of ventilator days in a level 1 trauma facility compared to normal-weight patients, with an average difference of three days (51).Given the consistency of these studies, early triage for obese patients, close monitoring, and early mobilization to the ICU unit might be necessary to improve trauma outcomes.

The effect of smoking on ICU admission and ventilator use is somewhat controversial in the literature. A recent study on 630,278 critically ill trauma patients in the US found that smoking was associated with a non-clinically significant increase in ICU stay duration of +0.1 days, similar to our finding of a non-significant increase of +0.18 days (40). However, that same study found that smokers had a decreased risk of mortality compared with non-smokers. Interestingly, in our study, we found that smoking was associated with a lower risk of ventilator use in trauma patients. Several other studies reported similar findings, such as a study on 282,986 trauma patients by Grigorian et al., which found that smokers had one day less of ventilator use compared to non-smokers (52). In contrast, a study by Resnick et al. showed that smokers required five days longer mechanical ventilation than non-smokers (41). These mixed findings may be due to different doses of smoking, as variables such as packs per day and years of smoking were not included in any of these studies. Additionally, smoking may cause chronic physiological adaptations in the respiratory system, resulting in a lower chronic baseline oxygenation status, with smokers potentially requiring less ventilator use compared to non-smokers who experience a sudden drop in their oxygenation levels. These findings necessitate future basic science and translational studies to clarify the effect of smoking on ventilator use. Also, to the best of our knowledge, we did not find any relevant studies on the effect of compounded cardiovascular risk factors on ICU stay duration, and ventilator use in trauma patients.

Limitations of the study

The retrospective design of our study prevented us from establishing causality, limiting our findings to associations between previous medical comorbidities and trauma outcomes. Due to the small sample size, we were unable to study each disease separately, as some diseases might have mixed effects on trauma outcomes even within the same category. For example, different substances used by patients within the substance use disorders category, such as stimulants versus depressants, might have varying effects on trauma outcomes. Additionally, the severity of each condition was not controlled for, as we lack information about specific disease grades, which may affect trauma outcomes only at certain levels of severity. Multiple comorbidities from different categories can coexist (e.g., cardiovascular and respiratory diseases, neurological and respiratory diseases), potentially synergistically affecting trauma outcomes and posing challenges in attributing specific disease categories to these outcomes. Reporting bias can adversely affect certain variables, such as mental disorders and substance use disorders, potentially distorting the relationship between these comorbidities and trauma outcomes. The potential influence of uncontrolled confounding variables, such as socioeconomic status and place of residence, on both medical comorbidities and trauma outcomes cannot be determined due to the lack of data on these factors and the omission of all personal identifiers from our dataset. Finally, our study includes data from only a single trauma center during a specific time period, which may limit the external validity of our findings, particularly considering the diverse nature of the US population and variations in economic status and healthcare systems among different states.

Conclusion

Our study analyzed the effect of medical comorbidities on trauma outcomes. Patients with medical comorbidities had significantly longer hospital stays, with an increase of 1.42 days on average, when compared to patients without comorbidities. Furthermore, patients with preexisting medical comorbidities had higher odds of ICU admission (OR 1.35). ICU stay duration was also longer for these patients, showing an increase of 0.27 days on average. Regarding ventilator use, only patients with substance and drug use disorders had higher odds (OR 1.35) of ventilator use, whereas other conditions did not show significant associations. The duration of ventilator use was not significantly prolonged for most conditions, except for patients with obesity (+0.79 days). Given these findings, targeted interventions and specialized monitoring protocols tailored to specific comorbidities could potentially optimize trauma patient outcomes, lower ICU admissions, and reduce costs. For instance, early intervention strategies could be implemented for obese patients to mitigate prolonged hospital stays, while closer monitoring of trauma patients with cardiovascular diseases may enhance clinical outcomes and reduce the need for ICU admissions, ultimately leading to cost savings in healthcare delivery. Further research is essential to explore the distinct effects of each medical condition and management strategies separately on trauma outcomes.

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