

Effect of the COVID-19 pandemic on the management and outcomes of patients with traumatic injuries (Review)

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Abstract. During the COVID-19 pandemic, ~10% of the global population was officially affected, resulting in diverse changes, ranging from shopping habits to stringent hospital protocols. This article sought to provide a concise summary of relevant data concerning the interplay between COVID-19 and trauma, encompassing the entire trajectory from presentation to hospital discharge. Throughout the pandemic, there was a noticeable reduction in trauma presentations, while the ranking of injury mechanisms remained largely unchanged. To ensure essential surgical support, protocols were adjusted accordingly. Although there were some less significant changes in injury severity score, hospital length of stay, intensive care unit stay and mortality, the overall patient outcomes appeared to improve. In conclusion, the COVID-19 pandemic led to a decline in trauma cases and an enhancement in patient outcomes. However, regrettably, certain mechanisms of injury saw an increase in frequency. To cope with the epidemiological context, management strategies were adapted, and unutilized resources were redirected to cater to the care of COVID-19 patients.

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1. Introduction

In December 2019, Wuhan, China, became the geographic epicenter of unusual pneumonia cases caused by a novel coronavirus species, later known as COVID-19. Due to its rapid global spread, on January 30, 2020, the World Health Organization (WHO) declared the outbreak a public health emergency of international concern, and on March 11, 2020, COVID-19 was declared a pandemic (1), becoming the most significant event in medical history since the Spanish Flu. Romania reported its first confirmed COVID-19 patient on February 26, 2020 (2) and as the number of cases rapidly increased, governments worldwide made efforts to protect their citizens and prevent the spread of the virus by imposing travel restrictions or stay-at-home orders. Since then, over 765 million confirmed cases of COVID-19, including 6.9 million mortalities, have been reported to the WHO (3).

Additionally, COVID-19 has had a significant effect on the demand for medical services, with a disproportionately higher need for non-surgical specialties and critical care compared with surgical specialties. Consequently, resources have been flexibly allocated to meet the demand (4). The arguments for redistribution were driven by contextual policies to halt the spread of the virus and ultimately by reduced trauma presentations. However, medical professionals have expressed concern about the impact of COVID-19 on healthcare systems, particularly in terms of providing emergency medical services

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for trauma presentations (5,6). Based on these concerns, the present study formulated the following research questions: Has the COVID-19 infection affected the number of patients presenting to the hospital with trauma? What could be the cause of this phenomenon? How has the COVID-19 pandemic psychologically influenced the injury mechanisms occurrence? Has the dynamics of injury mechanisms changed during the pandemic compared with previous reference periods? Has the SARS-CoV-2 infection influenced the surgical therapeutic protocol for patients presenting with trauma? Has the severity of trauma been altered through changes in the injury mechanisms? What have been the outcomes of the pandemic's influence on trauma patients? Are there sufficient evidence to support the fact that COVID-19 infection can affect the outcomes of trauma patients?

The objective of the present review was to assess how the COVID-19 pandemic has influenced the epidemiology of traumatic injuries. It conducted a review of the current literature regarding the volume of trauma admissions in adults, injury mechanisms occurrence, surgical needs, and outcomes during corresponding pre-pandemic periods.

2. Methods

For an improved understanding of how the COVID-19 pandemic has affected the characteristics of presentation and management of trauma injuries, a detailed review was conducted.

An extensive search was performed on Google Scholar, PubMed, and ScienceDirect Freedom Collection (Elsevier) databases for articles on trauma injuries that compare two periods: The COVID-19 pandemic period and the pre-pandemic period. The search terms used included 'traumatic injuries,' 'trauma,' 'COVID-19,' 'SARS-CoV-2,' 'pandemic' and 'comparison.'

The data helped towards an improved understanding of the effect of COVID-19 on admissions, management and outcomes of patients with trauma injuries. Excluded from the results were articles in languages other than English, conference abstracts, posters, questionnaires and surveys. The publication date was disregarded. The title and abstract of the articles were reviewed, and those that did not meet the inclusion criteria were excluded from the final analysis. Only articles that met the criteria were retained, after evaluating the full text.

The collected data included results from various parts of the world, demographic information about patients, injury outcomes, injury mechanisms occurrence, intensive care unit admissions, trauma management, length of hospital stay, and comparisons with non-lockdown periods. Additionally, the studies were organized into four regions based on their origin: Americas, Europe, the Middle East and Asia.

In the specialized literature, a total of 684 articles on this topic were identified, out of which 56 had keywords related to trauma and the pandemic. The full text of these studies was extracted. For the final analysis, 22 studies were selected, consisting of 21 observational studies and 1 experimental study. The selected studies compared the COVID-19 lockdown period in the country of origin of the article with the same period between 1 and 4 years before the lockdown.

3. Changes in trauma due to COVID-19

During the quarantine period, presentations of major trauma decreased, however after the lifting of restrictions, a return to pre-quarantine levels was observed, with a difference of 91% between the two periods. Road accidents and falls from height were the main contributors to this phenomenon, with changes of 184 and 50%, respectively. These percentages suggested a return of activity to previous levels and a possible increase in risk appetite in the case of falls from height (7).

In Italy, various centers reported a ~50% decrease in major trauma presentations and an increase in Injury Severity Scores (ISS) (8). In Spain, after the declaration of a state of emergency, Nuñez *et al* reported a decrease in trauma presentations from road and work accidents at a Spanish Tertiary Trauma Center (9). A German study demonstrated a general decrease in trauma cases and injury mechanisms during the quarantine period (10). Mortality was lower amidst presentations after the quarantine was lifted. Analysis conducted in both periods revealed that advanced age and frailty were the factors most commonly associated with an increased risk of mortality (11). Another study reported a higher mean age of trauma patients during the pandemic compared with a pre-pandemic period. The authors hypothesized that the restrictions, including the suspension of all recreational and competitive sports activities and access restrictions to parks, which are usually a source of pediatric trauma, may have played a role (12).

4. Psychological impact of the pandemic on trauma

The unknowns of the novel coronavirus and frequent use of social media have exposed individuals to possible misinformation and fake news, thereby increasing feelings of anxiety and stress. Stressful or traumatic events, regardless of their duration, have prompted individuals to take protective measures for themselves and their loved ones. Contextual policies have led to a decrease in demand for certain services and products, exerting a significant impact on the local and global business environment (13).

Women, the most affected category. Service, healthcare, and retail industries, where the majority of the workforce consists of women, have been the most affected during the pandemic. As a result, women have exhibited increased vulnerability in developing anxiety, depression, and mental disorders compared with men. Low socioeconomic status, unemployment, and low educational level are risk factors that may contribute to the exacerbation of mental health issues, particularly depression and anxiety. A decrease in quality of life, linked with financial uncertainty, has further intensified the psychological distress experienced by individuals (13). A study conducted on an Italian cohort revealed that levels of stress, depression, anxiety and fear of COVID-19 were contagious and remained constant during the early stages of the pandemic (14).

Repercussions of covid-19 on the brain. The disease resulting from COVID-19 infection presents two types of psychological manifestations (15). The first is represented by symptoms of isolation and quarantine, manifested by depression, anxiety, loss of appetite, fear, stress and restlessness. The second

describes the psychiatric disorder caused by SARS-CoV-2 infection on ACE2 receptors in brain tissue and has been described in a group of individuals with psychosis in Spain (16). An observational study on a group of isolated patients revealed suicidal thoughts and depressive symptoms in some of them, indicating that isolated or quarantined individuals need psychological support and follow-up during and after the quarantine period (17,18).

Aggression caused by Covid-19. During the first month of the pandemic, a statistically significant decrease in emergency calls and arrests for aggression and assault was observed (19.1 assault calls and 16.4 assault arrests per month pre-COVID-19 vs. 18.7 assault calls and 15.6 assault arrests per month during COVID-19 in the city of Burlington, Vermont) (19), which was due to changes in routines and social interactions. The limitation of interactions with other individuals during the COVID-19 pandemic reduced violence in public spaces (e.g., bars and restaurants), since potential victims remained at home. However, the emergency calls for domestic violence increased, but arrests did not, as victims and aggressors were in the same location without capable guardians (police patrols, security guards, door staff, co-workers, friends and neighbours), in a stressful epidemiological context. Emergency calls reporting aggression returned quickly to pre-pandemic levels with the relaxation of restrictions, while the calls for domestic violence decreased. Domestic violence was among the most underreported crimes, with only half of the cases being reported to the police (19). Travel constraints and stress had an impact on domestic violence and aggression, with women being the most vulnerable category (20-22).

Studies indicated a general increase in injuries caused by assault and self-harm, with similar results regarding other injury mechanisms such as sports-related injuries (23-26) and other less common mechanisms. However, a statistically significant increase in cases of firearm-related injuries and intentional or accidental stabbings was observed [for instance, a significant increase in gun-related injuries was observed, 6 vs. 9%, in a study by Mokhtari *et al* (27)]; most of the findings in the present study came from studies conducted in the USA, where firearm legislation is more relaxed (23-43).

5. Injury mechanisms and their impact on presentations

Trauma injuries, based on continuity solutions, can be classified into blunt and penetrating injuries. During the COVID-19 pandemic, there was a global increase in penetrating injuries (16.62 vs. 13.18%), while blunt injuries decreased (80.4 vs. 83.95%) (23-43). Injury mechanisms varied and included falls from ground level and from heights, as well as traffic-related injuries, which were further divided into subcategories such as motor vehicle accidents, motorcycle accidents, bicycle accidents and pedestrian accidents. Additionally, injuries caused by violence were also reported. These mechanisms of injury were the most frequently observed, followed by trauma injuries caused by stabbing, firearms, sports-related injuries, self-harm and others (23-43).

Various injury mechanisms. The discrepancy regarding other injury mechanisms can be clarified through further analysis.

Firstly, in order to define other mechanisms, they may include burns, explosions, animal bites and injuries caused by natural phenomena. The data we found suggested that these manifested a slight decrease (5.28 vs. 5.63%) (23,24,26,27,30-32, 35,38-41). The most frequent injury mechanisms found in the literature were falls, traffic-related injuries, assaults, gunshot wounds and stabbings. Second, the results primarily come from the USA due to more comprehensive analyses of injury mechanisms conducted by insurance companies (41). Other studies may present different results from those included in the present review.

Fall-related trauma. The incidence of fall-related injuries during the pandemic increased primarily due to stay-at-home orders and spending less time outdoors. Falls from the ground level were frequently associated with the place of residence or nearby and recreational activities (44), while falls from height were associated with the workplace, various activities and self-harm. In the USA, the most common mechanism of injury, falls from the ground level (44), showed a slight decrease, while falls from height remained almost unchanged (35.9 and 31.4% vs. 36.33 and 31.04%) (23,26-29,31,33,34,35,37,39,41). In Europe, decreases were observed only in falls from height (23 and 20.45% vs. 23 and 24.25%) (25,42), while in the Middle East, there was a decrease in falls on the ground level and a slight increase in falls from height (20.40 and 24.93% vs. 23.05 and 23.24%) (25,32,34,39). In Asia, there were no differences in falls on the ground level, only a small difference in falls from height (30.5 and 15.97% vs. 30.5 and 16.07%) (24,40,43). The highest increase in fall-related injuries was reported by Giudici *et al* (42) in an Italian center (43.50 vs. 24.90%), followed by Mazzolini *et al* (31) (37.70 vs. 31.50%). In Europe, Riuttanen *et al* (30) observed a significant decrease (5 vs. 16%) in falls from height; in the Middle East, Baradaran-Binazir *et al* (32) observed an increase (23.30 vs. 19%) and in Asia, discrete decreases were observed in falls on the ground level and falls from height by Walline *et al* (24) (44.5 and 4.5% vs. 44.7 and 5.5%; Table I).

Trauma from road accidents. With over 11 million kilometers of operational roads open to the public (45) and more than 280 million vehicles (46), the USA has the highest number of road traffic accidents in the world involving injury to individuals and property damage, excluding vehicle suicide attempts (47).

During the COVID-19 pandemic, a segment of traffic-related injuries decreased in the USA (motor vehicle crashes, motorbike accidents, bicycle accidents, auto/pedestrian accidents; 19.07, 5.8, 8.87 and 8.49% vs. 20.10, 6.69, 7.77 and 10.33 %) (23,26-29,31,33,35-37,39,41). In Europe, especially injuries involving automobiles, there was a decrease from 44.56 to 29.60% (30,42). In the Middle Eastern region, notwithstanding the escalating percentage of incidents encompassing motor vehicles, motorbikes, bicycles and auto-pedestrian collisions, there was a discernible decrease in the resultant injuries (26.78, 3.27, 1.49 and 6.18% vs. 23.93, 3.47, 1.63 and 3.17%) (25,32,34,38). In Asia, there were also decreases in injuries (18.43, 10.15, 3.8 and 9.95% vs. 16.03, 8.6, 2.95 and 12.3%) (24,40,43).

Table I. Comparative analysis of trauma outcomes related to falls pre-pandemic compared with during the COVID-19 pandemic.

Region	Type of fall	Pre-pandemic percentage	Pandemic percentage	(Refs.)
USA	Falls from ground level	35.9	36.3	(23-41)
USA	Falls from height	31.4	31.0	(23-41)
Europe	Falls from height	23.0	20.5	(25,42)
Europe	Falls from ground level	24.3	23.0	(25,42)
Europe	General falls	24.9	43.5	(42)
Europe	General falls	31.5	37.70%	(31)
Europe	Falls from height	16.0	5.0	(30)
Middle East	Falls from ground level	23.1	20.4	(32,33,25,38)
Middle East	Falls from height	23.2	24.9	(32,34,25,38)
Middle East	Falls from height	23.3	19.0	(32)
Asia	Falls from ground level	30.5	30.5%	(24,40,43)
Asia	Falls from height	16.1	16.0	(24,40,43)
Asia	Falls from ground level	44.7	44.5	(24)
Asia	Falls from height	5.5	4.5	(24)

Indian railways, the second-largest railway company in the world, along with air transportation, were also paralyzed by government directives. Schools, universities, industries, and commercial activities were closed, forcing the population to adopt remote work. Weddings, funerals and other public gatherings were also prohibited and all these restrictions led to a decrease in the number of road accidents (48).

Prior to the pandemic in India, 53.2% of trauma injuries were caused by road accidents. During the lockdown, the percentage decreased to 39.4%, yet the decline was transitory and, after the relaxation of restrictions, returned to previous levels. However, road accidents involving two-wheeled vehicles increased during the lockdown period due to their essential use by the public for transportation purposes. In second position, after road trauma, were fall-related injuries, which showed a percentage increase (31.2 vs. 26.2%), and numerically decreased (377 vs. 600) (49). There were also increases in the number of collisions between motorcycles and bicycles in countries like South Korea, where food and small goods delivery by couriers on motorcycles or bicycles experienced unprecedented growth, mainly due to the epidemiological context and fear of the new virus. It can be said that social distancing and quarantine measures have led to an increase in the number of injuries from accidents involving two-wheeled vehicles and a decrease in pedestrian-related injuries (40).

The most notable decreases were recorded in the study conducted by Riuttanen *et al* (30) (23 vs. 29%) from the Faculty of Medicine and Health Technology and Tampere University Hospital, Finland and in the study by Giudici *et al* (42) in an Italian center (36.2 vs. 60.30%). Contrary to expectations, increases in traffic-related trauma was observed during the pandemic, in the USA, as shown in the study by Hahn *et al* (28) (29.90 vs. 25.80%) and in the study by Park *et al* (40) (12.5, 12.5, 4.4 and 11.30% vs. 9.4, 9.4, 3.2 and 14.2%). Modest increases were also observed in centers in the USA and Hong Kong (29.3 vs. 28.6% and 32.2 vs. 27.3%), as reported by Williams *et al* (23) and Walline *et al* (24) (Table II).

Trauma due to violence. Previous studies have demonstrated that social limitations and mobility restrictions disproportionately affect low-income families and employees by reducing income and increasing social isolation (50,51). Others have hypothesized that policies that result in social isolation and financial insecurity may increase intentional acts of violence and self-harm (24,52).

Unsurprisingly, worldwide, the incidence of violence/aggression and self-inflicted injuries increased during the period of isolation, according to the data (9.17 and 3.43% vs. 8.72 and 1.97%) (23-43), which is in line with other studies highlighting the negative psychological impact of home isolation caused by COVID-19 worldwide, which could have led to an increase in violence-related injuries (38). The increase globally in accidental or intentional stabbing injuries has also risen (6.57 vs. 5.63%) (25,27-32,35,38,39,41-43). Giudici *et al* (42) demonstrated a similar trend of penetrating injuries, especially stabbings, that occurred within families during the pandemic (10.4 vs. 5.2%).

Firearms-related trauma. Shortly after the enactment of quarantine and social distancing orders, numerous trauma centers in major US cities reported an increased number of violence-related injuries, including firearm-related injuries (53-57). The pandemic sparked a surge in firearm purchases in the USA, already a heavily armed country. Between March and July 2020, >4 million firearms were sold nationwide, exceeding the normal levels, which resulted in a directly proportional increase, surpassing normal expectations, of >4,000 cases of firearm-related injuries during the same five-month period. As a result, firearm-related injuries in the USA witnessed a 27% increase in the early months of the pandemic compared with the corresponding pre-pandemic period, indicating a causal relationship between domestic firearm violence and the excessive acquisition of firearms (58). There have been notable changes in the prevalence of firearm-related traumatic injuries during the pandemic. The majority of gunshot injuries were recorded in US hospitals

Table II. Comparison of trauma outcomes from road accidents pre-pandemic vs. during the COVID-19 pandemic.

Region	Type of fall	Pre-pandemic percentage	Pandemic percentage	(Refs.)
Asia	Overall injuries	8.43	0.15	(24,31)
Europe	Automobile-related injuries	44.6	29.60	(30,35)
Hong Kong	Traffic-related injuries	27.3	33.2	(24)
India	Traffic-related injuries	53.2	39.4	(39)
India	Falls-related injuries	26.2	31.2	(41)
Italy	Traffic-related injuries	60.3	36.2	(42)
Middle East	Motorcycle and bicycle injuries	26.8	3.27	(25,32,36)
USA	Traffic-related injuries	19.1	5.8	(28,31,36)
USA	Motor vehicle crashes	25.8	29.9	(28)
USA	Traffic-related injuries	28.6	29.3	(26)

(8.13 vs. 6.33%) (23,26-29,31,33,35,36,37,39,41) reflecting the country's highest number of firearms per capita, with 120.5 firearms per 100 residents (59). The largest increase was reported by Alfrey *et al* (36) (7.8 vs. 2.5%). In Europe, the percentage of firearm-related injuries tripled (2.0 vs. 0.6%) (30,42). Conversely, İlhan *et al* presented a non-significant increase in the Middle East (1.9 vs. 1.1%) (25).

Firearm injuries during the pandemic. Specialized literature and medical practice have described firearm-related injuries frequently associated with bleeding and the need for transfusion (60). DeMario *et al* (61) reported that penetrating gunshot trauma had a five-fold increased transfusion requirement and received nearly ten times more blood component units compared with non-firearm-related injuries. In a new epidemiological climate with limited resources, firearm-related injuries posed a challenge for trauma centers. In the USA, although elective surgical interventions were suspended in the spring of 2020, the national blood supply reached a historic low (62). Maintaining an adequate stock of blood products relies on a continuous collection rate from donors. The challenge arose with social distancing orders, which halted blood donation campaigns that had an ~80% success rate in collection (63,64). Firearm injuries posed an additional concern during the pandemic when resources were scarce. The increased number of firearm-related injuries added extra pressure on the limited stock of blood products. Therefore, in pandemic planning, it is essential to prioritize the supply of necessary products for the treatment of penetrating injuries, such as blood products or alternatives. Additionally, ensuring the availability of equipment necessary for reducing the transmission of infectious diseases is crucial in managing these cases (65).

Sports-related trauma. In South Korea, during the year 2020 in contrast to 2019, a notable decrease was observed in the participation of sports activities lasting at least 30 min per week, seeing a drop from 66.6 to 60.1%. Specifically, in South Korea, there was a substantial decline in indoor sports such as bodybuilding and swimming, driven largely by the nationwide restrictions on public gatherings and subsequent closures of sports and fitness facilities. These preventive measures

were South Korea's proactive strategy to curb the spread of the infection and to ensure public safety. Conversely, South Koreans displayed a surge in their preference for outdoor sports activities; for instance, the percentage of those engaging in jogging and running rose from 29.23% in 2019 to 35.7% in 2020. As a response to the pandemic, the world saw a halt in sports competitions, which resonated deeply within South Korea leading to a reduction in active sports participation. Adhering to the practice of social distancing, a unique trend emerged within the South Korean populace: a spike in the popularity and purchase of home fitness equipment, reflecting their resilience and adaptability in seeking avenues to maintain physical fitness amidst the challenging epidemiological conditions (66).

Epidemiologically safe sports. In the USA, sports-related injuries affect ~8.6 million individuals annually. However, in 2020, numerous sport disciplines faced difficulties, leading to a 34.6% decrease in the number of sports-related injuries compared with previous corresponding periods (67). Cycling was the only sport that experienced an increase in injuries. The decline in cases can be attributed to institutional recommendations to manage mild cases at home, as well as fears related to the new virus. The most affected body parts were the knee, foot and ankle, accounting for 31% of cases presented in emergency departments. The decrease in sports injuries among school-age children and the increase among young adults ≥23 years (college students) were attributed to school closures during quarantine periods and the transition to online classes. Notably, despite having the same method of study, college students experienced a rise in sports injuries. The majority of those affected by injuries were males (71.9%), probably due to a higher participation rate in sports activities (67). Unorganized sports activities that did not require specialized sports infrastructure experienced declines in injuries. However, these declines were offset by injuries in individually safe and epidemiologically-friendly sports such as running and cycling. The sudden surge in sports during lockdown by untrained individuals, driven by the epidemiological context, led to increased outdoor sport activities in multiple urban centers and subsequently resulted in a higher number of injuries (67).

6. Surgical therapeutic protocol

Changes in therapeutic management. During the global chaos of the first wave of COVID-19, the outcomes of acute abdominal pathology were negatively affected (6) and millions of elective surgical procedures were canceled (68). This move allowed the redistribution of resources and healthcare personnel towards the additional care needs of patients with COVID-19. Increased postoperative mortality due to pulmonary complications in patients with perioperative infection was addressed (69). Some hospitals prioritized emergency surgeries, while elective surgeries had become more vulnerable to COVID-19 infection (70). Meanwhile, other hospitals modified patient routes and operating room protocols (71) and implemented COVID-19-free methods (isolation of operating room, critical care and inpatient ward areas away from patients with COVID-19), ensuring that even patients in need of elective surgeries received treatment (72,73). All mandatory safety measures were strictly performed to reduce viral transmission, assuming that all patients were infected due to false-positive and false-negative tests. Healthcare personnel always used personal protective equipment (PPE) such as N95 masks, eye protections, gloves, and gowns, making the limitation of intra-hospital virus spread a priority (74). However, in some hospitals, infection-free protocols were not sufficient, as evidenced by the continued low number of elective surgeries (75).

The rational use of PPE was addressed with consideration for future needs. Cleaning and disinfection protocols were constantly updated, reviewed and adapted to prevent the spread from infected patients (76).

Surgical and post-surgical needs. According to reports, between 2.1 and 84.6% of trauma patients during the pandemic required surgical intervention. The need for surgical procedures showed a slight increase in the USA (27.62 vs. 26.88%) (26,28,31,41). In Europe, Giudici *et al* (42) did not report any changes in demand, while increases were observed in the Middle East (35.25 vs. 31.71%) (25,32,34,38) and Asia (38.7 vs. 29.6%) (24). Prior to the pandemic, 21.7% of patients required intensive care unit (ICU) admission. During the corresponding period of COVID-19, the percentage decreased to 20.4% (25,28,38,39,42) and the length of ICU stay decreased to 3.23 days from 4.15 days (24,26,28-30,32,35,38-41). It has been hypothesized that some patients, out of fear of potential COVID infection, may have avoided specialized medical care and only the more severe traumas that required urgent specialized medical aid and admission sought medical care (65). Although the COVID-19 virus has caused inadequate changes in elective surgical treatment and cancer treatment for patients (77), the present study has shown that during the pandemic, the treatment of individuals who have suffered trauma largely remained the same.

7. Outcomes

ISS. Out of the 15 analyzed studies that reported the ISS in patients presentations during the pandemic, 12 showed a similar or lower mean score compared with the

pre-COVID-19 period, while 3 centers in the Middle East and Asia experienced a slight increase (23,24,28-31,33,35-42). The hospital length of stay did not undergo significant changes, even though the time from presentation to surgical intervention decreased. This can be attributed to the specific population during that period, including elderly patients with complex injuries requiring extended postoperative recovery, for whom protocols could not be accelerated (12). The hospital length of stay was also influenced by the relocation of specialized recovery staff to vulnerable areas of overwhelmed medical services due to the magnitude of the pandemic. Additionally, pulmonary complications in patients with SARS-CoV-2 led to higher mortality rates and longer recovery periods (69,78). Modifications to anesthesia and intensive care protocols for patients testing positive for COVID led to extended durations under anesthesia (79). Anesthesia and post-anesthesia recovery were performed directly in the operating room to avoid unnecessary surface and space contamination. Cleaning protocols were modified so that after the surgical intervention, the operating room was left vacant, allowing airborne viral particles to settle and generous air exchanges to occur before cleaning began (80). Upgraded air filtration systems increased disinfection time, as well increased the time required for donning and doffing of anesthesia personnel due to additional protective measures. These aspects are crucial for the protection of healthcare personnel, as studies have shown an increased risk of infection during intubation protocols (12,81). All patients requiring general anesthesia were intubated, which extended the duration of anesthesia (12).

Length of hospital stay. The mean hospital length of stay was slightly lower during COVID-19 compared with the non-COVID-19 period, with a mean of 4.77 days compared with 5.05 days (23,24,26,29,31,32,35-39,41,43). It can be said that this reduction was in line with the lower average ISS score. According to the findings, there was generally a consistent or slight decrease in the ISS score in trauma patients during the pandemic, which was in tandem with hospital length of stay. Additionally, there was a reduced global need for ICU care during the pandemic, and the mean length of ICU stay was shorter (24,26,29,32,36,37,39,41). This could be attributed to the urgent demand for medical infrastructure for COVID-19 positive patients or a lower number of trauma admissions.

Mortality. The mortality rate as a result of trauma after hospitalization was 4% during the COVID-19 period, slightly improved from the corresponding 4.07% in the pre-COVID-19 period (23-29,31-35,37-43). Compared with the non-COVID-19 period, the highest mortality rate in the examined studies decreased (4.5 vs. 6.6%), as reported by Walline *et al* (24) in a center in Hong Kong. On the other hand, the lowest rate, 0.2% of all COVID-19 trauma admissions at a center in Turkey, was reported by İlhan *et al* (25) without any apparent change between the two periods.

According to the analysis, it appears that a lower ISS is associated with lower mortality, reduced need and length of intensive care, resulting lower hospital length of stay and lower hospitalization costs.

8. Interventions that could have enhanced the reported outcomes

In the context of the COVID-19 pandemic, significant challenges were observed in managing patients with traumatic injuries, often requiring intensive medical-surgical care. Reflecting upon this, it can be hypothesized that the following interventions could have ameliorated the reported outcomes.

Telemedicine appears to have been underutilized. If employed more systematically, virtual assessments and rehabilitations could have facilitated patient recovery from the comfort of their homes, simultaneously mitigating exposure to COVID-19 (82,83).

The adoption of more rigorous triage protocols could have been advantageous. Through this, the healthcare system might more efficiently identify and prioritize patients based on their needs while curbing potential virus exposure (84,85).

Interdisciplinary collaboration among medical specialists seems to have been an indispensable component that could have been strengthened. Closer collaboration across various disciplines might have expedited the care process and optimized resources amidst the pandemic (86).

More strategic pre- and post-operative management might have averted additional complications. Considering the potential impact of COVID-19 on surgical outcomes, a more meticulous evaluation of patients before and after surgery would have been desirable (87).

Regarding mental health, a more proactive approach would have been beneficial. Given the added strain on trauma patients during the pandemic, online therapies could have assisted in addressing associated stress and anxiety (88).

Training in preventive measures might have played a pivotal role. Enhanced training of medical staff in the use of personal protective equipment and the implementation of stricter protocols might have minimized contamination risk (89).

Additionally, promoting vaccination could have significantly affected the progress of the pandemic. By ensuring that medical staff and patients were vaccinated, the risk of transmitting the virus within medical institutions would have been substantially reduced (90).

In conclusion, educating patients and their families about risks and precautionary measures would have been essential to foster a more informed and preventive stance towards the pandemic (91).

9. Conclusions

The present review stands among the pioneering works delving into the implications of COVID-19 and associated policy frameworks on facets such as trauma presentations, injury causative factors, therapeutic strategies, and resultant outcomes. Within the pandemic milieu, the present study discerned a notable downtrend in trauma incidences, a diminished requirement for surgical interventions and enhanced survival rates. The pandemic-induced shift in social behaviors, particularly the increase in staying at home due to COVID-19-imposed constraints, precipitated a surge in trauma stemming from falls. These findings hold instrumental value for healthcare professionals, guiding the optimal allocation of resources and catering to patient requisites amid

pandemic exigencies. Significantly, telemedicine surfaced as a vital and effective alternative for delivering medical care to trauma patients amid the pandemic. The swift incorporation of telehealth solutions facilitated remote initial assessments, consultations, and patient monitoring, thus alleviating the burden on healthcare facilities and ensuring compliance with social distancing measures. These results highlighted the immense potential of telemedicine as a valuable instrument in managing trauma during pandemics, carrying profound implications for disaster preparedness and the allocation of resources. During the COVID-19 pandemic, there was a notable decline in trauma cases necessitating surgery, primarily attributed to the diversion of healthcare resources towards COVID-19 care and the postponement of elective surgeries. This underscores the significance of efficient multidisciplinary collaboration among healthcare teams. Successful coordination among trauma specialists, infectious disease experts, critical care physicians and other relevant professionals in resource allocation could significantly enhance patient outcomes during such challenging circumstances.

The constraints inherent to the present study are delineated next. A significant proportion of the examined research offers data from a constricted temporal window, primarily encompassing periods just before and during the early stages of the COVID-19 pandemic. This time frame might not adequately reflect the complete ramifications of the pandemic on trauma.

A notable gap in the selected studies is the lack of details regarding the operational status of healthcare institutions in the context of their engagement with COVID-19-related care. This omission is consequential, as trauma patients may have sought care from alternative institutions or might have refrained from hospital admissions due to contagion concerns, thereby potentially skewing the conclusions of the present study.

The bulk of the studies embraced for the present meta-analysis emanate from singular centers. Coupled with our selection criterion prioritizing English-language publications, this could mean potential omission of critical data points. Subsequent investigations would be enriched by embracing a more extended chronological scope, assessing the roles of healthcare facilities in relation to COVID-19, juxtaposing varied pandemic phases and juxtaposing data from periods unaffected by COVID-19.

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Authors' contributions

GJB, DCC, PN, VP, DR, AMB, IG and EFG analyzed data and wrote and revised the manuscript. All authors have read

and approved the final manuscript. Data authentication is not applicable.

Ethics approval and consent to participate

Not applicable.

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Competing interests

The authors declare that they have no competing interests.

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