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Paramedic and COVID-19 pandemic: Review article

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***Abstract*---Background:** The COVID-19 pandemic has overwhelmed Emergency Medical Services (EMS) worldwide, resulting in increased call volumes, delays, and disruptions in service delivery. This study explores the impact of the pandemic on EMS operations and identifies key factors contributing to these challenges. **Aim:** The objective is to analyze the disruptions in EMS services caused by the COVID-19 pandemic, examining various factors that influenced response times, service quality, and overall EMS efficiency during the peak of the crisis. **Methods:** A narrative review methodology was employed to synthesize findings from existing literature on EMS response during the COVID-19 pandemic. Factors affecting EMS operations were categorized into three primary groups: EMS-related factors, social dynamics, and patient-related factors. The review focused on analyzing these factors' impacts on EMS calls, response times, and overall service delivery. **Results:** The study identified five key themes affecting EMS during the pandemic: (1) Increased volume of EMS calls, (2) Decreased response times, (3) Delays in ambulance dispatch, (4) Increased collateral mortality and morbidity among non-COVID-19 cases, and (5) Prolonged total time for ambulance calls. These disruptions were attributed to a combination of high call volumes, resource constraints, and operational challenges exacerbated by the pandemic. **Conclusion:** The COVID-19 pandemic significantly impacted EMS operations globally, highlighting the need for improved crisis response strategies. The findings underscore the importance of enhancing EMS infrastructure, optimizing resource allocation, and implementing adaptive strategies to manage high call volumes and ensure timely responses during future emergencies.

***Keywords*---**COVID-19, Emergency Medical Services, EMS response, pandemic impact, service disruptions, crisis management.

Introduction

During the peak of the COVID-19 pandemic in 2020, there was an unprecedented surge in Emergency Medical Services (EMS) calls globally, leading to significant disruptions in the services provided by EMS dispatch centers and substantial delays in emergency responses worldwide. This study investigated the factors contributing to these disruptions in various countries and identified three primary categories:

- Factors related to EMS
- Factors related to social dynamics
- Factors related to patients

To provide a clearer understanding, each factor was analyzed based on the existing literature. Notably, a pattern emerged that led to the identification of five key themes: EMS calls during COVID-19, decreased response times by EMS operators, delays in ambulance response, increased collateral mortality and morbidity among non-COVID-19 cases, and the total time for ambulance calls. By examining these factors and their secondary effects on EMS calls, we aim to develop more effective crisis and disaster response strategies. This paper serves as a valuable resource for EMS decision-makers worldwide.

Emergency medical services (EMS) are crucial in disaster response, including pandemic situations [1–3]. The role of EMS personnel as initial responders to biological disasters is well-documented [4]. Throughout the progression of COVID-19, reports from various locations highlighted significant increases in EMS call volumes. For instance, in New York City (NYC), the daily EMS call volume escalated from a typical high of 4,000 calls to over 7,000 calls [5, 6]. Such dramatic increases in call volume exert immense pressure on EMS dispatch centers (EMSDC). The European standard of a 10-second optimal time-to-response (TTR) [7] is central to maintaining timely EMS services. Overloading with calls poses a significant risk to EMS operations, as any disruption to its primary goal of timely response severely impacts its effectiveness in the survival chain [8]. This study assesses the global impact of COVID-19 on EMS call volumes and the effects on dispatch centers and community health between March and June 2020. To the best of the author's knowledge, this is the first study to examine and elucidate this phenomenon. This paper offers a global perspective on public access to EMS during the COVID-19 pandemic. It aims to inform EMS managers and policymakers and provide a resource for managing current and future crises. Given the nature of the issue, a narrative review is considered the most appropriate method to synthesize findings and derive timeless lessons from the global EMS dispatch center bottleneck during such crises.

COVID-19 Severity:

The emergence of coronavirus disease (COVID-19), caused by the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has placed immense strain on global healthcare systems. The spread of the virus has been exacerbated not only by the presence of asymptomatic cases but also by inadequate widespread testing and personal protective equipment (PPE) for healthcare professionals worldwide [1]. The substantial influx of COVID-19 patients into hospitals underscores the need for a comprehensive understanding of the clinical, radiological, and laboratory findings associated with increased disease severity and mortality.

In this paper, we review the current literature to identify early demographic, clinical, virological, immunological, hematological, biochemical, and radiographic factors that may be linked to the severity of COVID-19. We adopt the World Health Organization's (WHO) definition of severe pneumonia to categorize severe disease. As of May 27, 2020, the WHO defines “severe disease” in adults as presenting with clinical signs of pneumonia (fever, dyspnea, cough, and rapid breathing) and meeting at least one of the following criteria: a respiratory rate greater than 30 breaths per minute, severe respiratory distress, or an oxygen saturation (SpO2) of 90% or less on room air [2]. While the precise determinants of severe disease are not fully understood, evidence suggests that host factors, rather than viral genetic mutations, predominantly drive disease progression [3]. However, preliminary data from a non-peer-reviewed study indicate that a D614G mutation in the viral spike (S) protein, observed in strains from Europe and the United States but not China, may enhance transmission efficiency [4]. Identifying potential risk factors that predict the course of the disease could be invaluable for healthcare professionals. It would enable more effective patient triage, personalized treatment, clinical monitoring, and resource allocation to reduce morbidity and mortality. This review synthesizes current literature on patient factors proposed as predictors of COVID-19 severity and mortality.

Common Symptoms of COVID-19

The most frequently reported clinical manifestations of COVID-19 are fever, dry cough, and fatigue. Other, less common symptoms include headache, dizziness, abdominal pain, nausea, and vomiting [5]. Some patients may also experience anosmia (loss of smell), dysgeusia (altered or loss of taste), nausea, and diarrhea a few days before the onset of fever. Although fever is a significant indicator of COVID-19, it may not always be present. For instance, among 191 patients hospitalized in Wuhan, China, in January 2020, 94% exhibited fever upon admission [6]. It is important to note that this statistic pertains exclusively to symptomatic, hospitalized individuals. A small subset of hospitalized patients may report additional symptoms such as dyspnea, headache, sore throat, congestion, and hemoptysis, while others may remain relatively asymptomatic [6-8]. These symptoms are not unique to COVID-19 and can overlap with those of other viral and bacterial infections.

Clinical Factors Predict COVID-19 Severity:

Demographics:

Certain demographic characteristics have been identified in the literature as being associated with a higher likelihood of severe COVID-19 outcomes [9-14]. Notably, advanced age is a significant predictor of mortality and is a key component of clinical severity risk scores [10, 14-22]. For instance, as of March 16, 2020, 62% of COVID-19 patients hospitalized in the United States were over the age of 55, while fewer than 1% were 19 years old or younger [23]. In a retrospective cohort study of 1,591 critically ill COVID-19 patients in Italy, the median age was 63 years [22]. Additionally, evidence indicates that male sex is independently associated with increased COVID-19 severity [24, 25].

Comorbidities:

Pre-existing health conditions such as cardiovascular disease, chronic kidney disease, chronic lung diseases (especially chronic obstructive pulmonary disease, COPD), diabetes mellitus, hypertension, immunosuppression, obesity, and sickle cell disease are known to predispose individuals to a more severe clinical course and an increased risk of intubation and mortality [6, 8, 10, 26-31]. The Centers for Disease Control and Prevention (CDC) has updated its list of risk factors for severe COVID-19, highlighting body-mass index (BMI) greater than 30, which indicates obesity, as a strong predictor [31]. A study conducted in Mexico found that among 32,583 patients with at least one comorbidity, obesity, diabetes, and hypertension were significant risk factors for both contracting the infection and developing severe disease [32]. The CDC also identified sickle cell anemia, moderate-to-severe asthma, and pregnancy as risk factors for severe illness [31].

Elevated levels of glycosylated hemoglobin (HbA1c), a marker of long-term blood glucose control in diabetes, have been linked to increased inflammation, hypercoagulation, and higher mortality (27.7%) [33]. The American College of Cardiology reported in March 2020 that case fatality rates were higher among patients with pre-existing conditions compared to those without. Fatality rates were highest for individuals with cardiovascular disease (10.5%), followed by diabetes (7.3%), COPD (6.3%), hypertension (6.0%), and cancer (5.6%). In contrast, patients without pre-existing conditions had a fatality rate of less than 1% [34]. Cancer is recognized as a significant comorbidity associated with adverse COVID-19 outcomes. A nationwide analysis in China revealed that patients with various types of cancer, particularly hematological and pulmonary malignancies, are more likely to experience severe COVID-19 complications compared to those without cancer [35]. This trend has been corroborated by other studies [36-39]. Advanced tumor stage is associated with worse outcomes [37]. However, it is suggested that COVID-19 mortality in cancer patients may be more closely related to male sex, comorbidities, and advanced age than to chemotherapy or cytotoxic treatments [40]. Solid organ transplant recipients also appear to be at increased risk for COVID-19 complications [41]. Efforts have been made to develop prediction models incorporating various clinical and laboratory parameters. A multicenter study in China created and internally validated a prediction nomogram based on symptoms, vital signs, and comorbidities among 366 laboratory-confirmed COVID-19 patients in emergency departments. This model achieved a Harrel's concordance-index (C-Index) of 0.863 (95% CI, 0.801-0.925), indicating good discrimination and calibration [42].

Hypoxia:

There is a strong correlation between hypoxemia and worse clinical outcomes in COVID-19 [19, 43]. A study of 140 patients with COVID-19-associated pneumonia found that oxygen saturation (SpO2) above 90.5% was predictive of survival with a sensitivity of 84.6% and specificity of 97.2%. Conversely, dyspnea was independently associated with mortality in multivariable analyses [43]. Among critically ill patients in Italy, the median partial pressure of oxygen to fraction of inspired oxygen ratio (PaO2/FiO2) was 160 mmHg with a median positive end-expiratory pressure (PEEP) of 14 mmHg. Younger patients had a higher PaO2/FiO2 ratio (163.5) compared to older patients (156) [22]. In this study, older patients (n = 786, aged 64 years and older) were more likely to die compared to younger patients (n = 796, aged under 64 years), with mortality rates of 36% versus 15%, respectively (difference of 21%; 95% CI 17%-26%; $P < 0.001$) [22].

Radiographic Features of Severe Disease:

For the purpose of detecting noteworthy results linked to severe COVID-19 disease, imaging techniques are essential. On April 7, 2020, guidelines regarding the use of computed tomography (CT) and chest x-ray (CXR) in COVID-19 patients were released by a multidisciplinary panel of radiologists and pulmonologists from ten different countries. The panel recommended that patients who have declining or compromised respiratory function, or who are at risk of their condition progressing, should have chest imaging [44].The panel noted that CT is more sensitive in the early stages of the disease, even if CXR can be helpful for tracking disease progression [44]. Ground-glass opacities and bilateral consolidation are frequent observations on CT, especially in the peripheral lower lung areas [45, 46]. Chest imaging, however, may show normal in patients with minimal symptoms or in the early stages of the disease. An increased risk of intensive care unit (ICU) admission and advanced age have been linked to the presence of pulmonary fibrosis [47]. In contrast to a minority of survivors, several of the small number of died COVID-19 patients in a recent research had consolidation and air bronchograms on chest imaging. Patients who died from the illness had higher median CT scores, which indicate the level of attenuation and consolidation in certain lung areas [48]. There have been reports of specific CT abnormalities in critically ill patients, including traction bronchiectasis (a kind of bronchiectasis defined by bronchial dilatation inside afflicted lung parenchyma), broad distribution of abnormalities, and involvement of lymph nodes. Furthermore, there has been mention of architectural distortion, which is defined by the American College of Radiology as disturbances in the typical structure of the lung. This involves "spiculations radiating from a point and focal retraction or distortion of the edge of the parenchyma" [49]. In Wuhan, China, 81 individuals were studied retrospectively, and it was discovered that lymphadenopathy and pleural effusions were unusual CT findings [50]. An expanded pulmonary artery diameter, which may be a sign of pulmonary arterial hypertension, has been associated with COVID-19 mortality, according to an Italian investigation of 627 probable cases of the virus [51]. Moreover, another study with 302 Italian patients showed that the probability of in-hospital death in COVID-19 patients may be predicted by combining a novel CXR grading system (the Brixia 18-point severity scale) with older age and immunocompromised condition [52].

Laboratory Data:

Certain laboratory markers have been identified as potential predictors of COVID-19 prognosis [53]. Elevated levels of D-dimer, C-reactive protein (CRP), lactate dehydrogenase (LDH), and high-sensitivity cardiac troponin I are commonly associated with adverse outcomes [5, 6, 8, 10, 11, 54-57]. However, it remains to be confirmed whether these and other biomarkers are directly involved in the pathobiology of SARS-CoV-2 infection.

Coagulation Defects:

Large-vessel stroke and coagulation anomalies have been reported in SARS-CoV-2 patients, suggesting that thrombosis indicators may be important for prognosis even in younger patients [58, 59]. In COVID-19, elevated D-dimer levels are linked to a poor prognosis [20, 55, 57, 60]. This suggests that elevated D-dimer concentrations could be a sign of concomitant venous thromboembolisms that cause ventilation-perfusion mismatch [54]. D-dimer levels have been suggested by several researchers as a tool for patient triage [61]. In a research with 343 COVID-19 patients, it was discovered that, whereas only 1 out of 267 patients had D-dimer levels <2.0 μg/mL ($P < .001$; hazard ratio, 51.5; 95% CI, 12.9-206.7) at the time of admission, 12 out of 67 patients with such levels died [62]. A different study found a correlation between higher in-hospital mortality and D-dimer levels ≥ 1.0 μg/mL at admission [6]. In COVID-19 patients, other coagulation parameters such thrombocytopenia and extended prothrombin time are also linked to an increased risk of death [53, 63, 64]. Furthermore, it has been demonstrated that recovery of platelet counts after hospitalization predicts survival [65]. Rather than consumptive coagulopathy, severe COVID-19 is frequently characterized by hypercoagulability, which increases the risk of thrombosis and excessive fibrin polymerization [66–69]. Severe endothelial injury is indicated by higher von Willebrand factor concentration and activity, low Protein C activity, and high levels of Factor VIII [70, 71]. These results imply that vascular endothelium, a crucial regulator of thrombosis and hemostasis, may be impacted by SARS-CoV-2 [71, 72].

Cardiac Dysfunction:

It is postulated that the severity of COVID-19 is correlated with markers of cardiac dysfunction [73]. There is increasing evidence of COVID-19-related cardiac problems, such as fulminant myocarditis and severe systolic dysfunction [74, 75–77]. Despite variations in patient presentations, ST-segment elevation is linked to a poor prognosis in COVID-19 individuals [78]. There is a substantial correlation between COVID-19 mortality and impaired left and right ventricular function as well as tricuspid regurgitation (> grade 1) [79]. The exact triggering reasons for acute cardiac damage were not identified in a retrospective cohort research involving 138 patients, although it was discovered that patients in the ICU had a higher risk of experiencing it than patients who were not in the ICU [5]. Furthermore, higher than the underlying cardiovascular disease alone, increased troponin levels (serum levels >99th percentile; >28 pg/mL) may be a more reliable indicator of a bad prognosis and an independent predictor of in-hospital mortality [80, 81]. Assessing the progression of COVID-19 may need routine transthoracic echocardiography and electrocardiography [79, 82–85]. High troponin I levels were strongly linked to unfavorable outcomes (OR = 5.22, 95% CI = 2.73-7.31, P <.001), according to a meta-analysis involving 17,794 patients. Elevated troponin I levels (>13.75 ng/L) were also strongly predictive of a poor prognosis when paired with elevated AST levels (>28 U/L) or older age (>60 years) [86].

Alterations in White Blood Cell (WBC) Counts:

The severity of COVID-19 may be predicted by white blood cell levels. Research shows that granulocyte counts are frequently lower in severe instances than in mild ones [7, 8, 87, 88]. Reduced blood lymphocyte percentages are connected with worse outcomes, and severity is also linked to lymphopenia [89, 90]. In severe cases, there are considerable reductions in total lymphocytes, CD4+ and CD8+ T cells, B cells, and NK cells, with T cell subsets exhibiting the highest losses, according to a recent meta-analysis of 20 peer-reviewed studies [91]. Poorer results are correlated with decreased numbers of CD4+ and CD8+ T cells as well as decreased functional diversity among these cells [87, 92-94]. On the other hand, elevated neutrophil and basophil counts could indicate severity. According to a study of 81 patients, patients with a high neutrophil-to-lymphocyte ratio (>9.8) were more likely to experience non-mechanical and mechanical ventilation at higher rates (P =.002 and P =.048, respectively) and to develop acute respiratory distress syndrome (ARDS) (P =.005) [88]. Lower peripheral blood eosinophil counts (<0.02 × 10^9/L) have been linked to longer hospital admissions, respiratory problems, and more severe chest CT lesions; however, this relationship may be influenced by steroid usage [95].

Liver Injury:

Patients with serious COVID-19 and end-organ damage are more likely to have elevated levels of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) [8, 96]. According to a study involving 329 SARS-CoV-2-infected patients, those with abnormal liver enzyme tests upon admission were more likely than those with normal liver enzyme results to require ICU admission (20% vs. 8%; $P < .001$), mechanical ventilation (14% vs. 6%; $P = .005$), acute kidney injury (22% vs. 13%, $P = .009$), and mortality (21% vs. 11%; $P = .009$). It has also been proposed that hypoalbuminemia, an established predictor of mortality in a number of patient populations [98], is a separate predictor of COVID-19 mortality [99, 100]. Because of this, some medical professionals are now thinking about albumin infusion as a possible preventative measure against mortality, however this theory is still up for debate [101]. Additionally, poor outcomes in COVID-19 cancer patients have been linked to a lower albumin-globulin ratio (0.12; 95% CI, 0.02-0.77; $P = .024$) [37]. An increased Liver Fibrosis Index (FIB-4) (≥2.67) was found to be an independent risk factor for severe COVID-19 in a multicenter, retrospective research including 160 patients between the ages of 35 and 65. A significantly greater risk of mechanical breathing and ICU hospitalization (37.8% vs. 18.3%, $P = .009$) was associated with elevated FIB-4 [102]. The formula for the FIB-4 index is as follows: (platelets [×10^9] × √ALT [IU/L]) / (age × AST [IU/L]).

Non-Specific Biomarkers of Cellular Injury:

In COVID-19, indicators of cellular injury—specifically, increased lactate dehydrogenase (LDH)—are linked to worsening disease severity [6, 9, 10, 20, 75, 81, 103]. In COVID-19 patients, LDH levels may be a useful indicator of respiratory function and a significant predictor of respiratory failure [104]. When age, LDH, and CD4+ were combined into a prediction model ([age × LDH] / CD4), the area under the receiver operating characteristic (ROC) curve was much larger than when each variable was taken alone. In patients infected with SARS-CoV-2, a threshold value of ≥82 yielded an 81% sensitivity and a 93% specificity for the early prediction of complex illness histories [42]. COVID-19 severity has also been associated with elevated α-hydroxybutyrate dehydrogenase, another sign of cellular injury suggestive of possible harm to kidney, heart, and red blood cells [12, 105]. Critically sick patients had higher levels of α-hydroxybutyrate dehydrogenase in a research with a small sample size [103].

Renal Dysfunction:

Severe COVID-19 instances have been linked to renal impairment and failure [6, 13, 75, 80, 106]. Urine biomarkers, like protein and glucose levels, can reveal information about the severity of COVID-19 [107]. SARS-CoV-2 may directly infect the renal tubular epithelium, according to histopathologic investigations, however renal impairment may also be a sign of systemic vascular and inflammatory consequences [106]. Therefore, biomarkers associated with renal anatomy and function may provide useful prognostic data.

Clinical Application of Prediction Tools to Risk Stratify Patients:

Prediction models are becoming increasingly important for risk stratification in COVID-19 patients. These models help in identifying patients at higher risk of severe outcomes and guiding clinical management.

Lymphocyte Percentage-Time Model: A lymphocyte percentage-time model has been proposed to assess disease severity based on lymphocyte levels over time:

- **Moderate Disease:** If the lymphocyte percentage is >20% within 10 to 20 days after symptom onset.
- **Severe Disease:** If the lymphocyte percentage decreases to 5% to 20% within 10 to 20 days after symptom onset.
- **High Risk of Mortality:** If the lymphocyte percentage decreases to <5% within 17 to 19 days after symptom onset [89].

Biomarker-Based Prediction Models: A non-peer-reviewed study involving 375 COVID-19 patients identified three key biomarker thresholds for predicting a favorable prognosis:

- **LDH < 365 U/L**
- **Lymphocytes > 14.7%**
- **High-sensitivity CRP < 41.2 mg/L**

This study developed a machine learning-based prognostic model with over 90% accuracy in predicting survival rates for severe COVID-19 patients [108]. Elevated CRP levels, whether alone or with other biomarkers, have also been linked to COVID-19 severity, and a correlation between elevated CRP and severe CT findings has been observed [20, 26, 55, 107, 109-111].

Cytokine Levels: COVID-19 can lead to cytokine release syndrome, making cytokine levels crucial for identifying severe complications:

- **IL-6 and IL-10:** Elevated levels of these cytokines are significant for early recognition of severe COVID-19 [26, 53, 57, 64, 94, 109, 112, 113].
- **IL-6/IFN-γ Ratio:** A high ratio is associated with severe COVID-19, though causation has not been established [114].
- **RANTES (CCL5):** Elevated early in mild-to-moderate cases but linked to severe disease [113, 94].
- **IL-10 and IL-1RA:** Increases in these markers early in the disease course are associated with severe outcomes [113].
- **IP-10 and MCP-3:** Persistent high levels of these cytokines are strong predictors of COVID-19 severity. At least 14 cytokines have been found elevated in critically ill patients [115].

These prediction tools and biomarkers assist in assessing the severity of COVID-19 and can guide clinicians in making informed decisions regarding patient management and treatment strategies.

Role of Paramedic in COVID-19:

Paramedics play a critical role in the emergency response to COVID-19, a role that has evolved significantly due to the pandemic. Their responsibilities encompass a range of tasks designed to address the unique challenges posed by the virus, including patient assessment, transport, and infection control. Understanding the multifaceted role of paramedics during the COVID-19 crisis provides insight into how emergency medical services (EMS) adapt to unprecedented public health emergencies.

Patient Assessment and Initial Care

One of the primary functions of paramedics in a COVID-19 emergency is the assessment and initial care of patients suspected of or confirmed to have the virus. This involves evaluating symptoms such as fever, cough, and difficulty breathing, which are indicative of COVID-19. Paramedics must use their clinical judgment to determine the severity of the patient's condition and decide on the appropriate course of action. Given the high transmissibility of the virus, paramedics are trained to use personal protective equipment (PPE) to protect themselves and others from infection. This includes masks, gloves, gowns, and face shields, which are essential for minimizing the risk of virus transmission during patient interactions.

Infection Control and PPE Usage

Infection control is a critical aspect of the paramedic's role during the COVID-19 pandemic. Paramedics must adhere to stringent protocols to prevent the spread of the virus within the ambulance and the wider community. This includes rigorous hand hygiene practices, the proper disposal of contaminated materials, and the regular decontamination of equipment and vehicles. The use of PPE is not just a personal protective measure but a standard procedure that ensures the safety of both the healthcare providers and the patients they serve. Paramedics are trained to don and doff PPE correctly and to follow established guidelines for infection control to reduce the risk of contamination.

Patient Transport and Coordination with Healthcare Facilities

Transporting patients with COVID-19 requires careful coordination with healthcare facilities. Paramedics must communicate with hospitals and other medical centers to ensure that there is a clear understanding of the patient’s condition and the required level of care upon arrival. This involves providing detailed information about the patient's symptoms, vital signs, and any interventions performed en route. Effective communication helps hospitals prepare for the patient’s arrival and allocate appropriate resources for their care. Paramedics must also navigate potential challenges such as managing patients with severe respiratory distress or other critical conditions while ensuring their safety and comfort during transport.

Handling COVID-19 Testing and Vaccination

In addition to their traditional roles, paramedics have been instrumental in COVID-19 testing and vaccination efforts. They have been involved in administering tests at various locations, including drive-through testing sites and mobile testing units. Paramedics' training in phlebotomy and specimen collection makes them well-suited for this task. Furthermore, as vaccines became available, paramedics played a key role in vaccine distribution and administration, particularly in underserved and remote areas. Their ability to provide vaccinations in various settings helps increase accessibility and coverage, contributing to broader public health efforts to control the pandemic.

Crisis Management and Mental Health Support

The COVID-19 pandemic has placed immense pressure on paramedics, both physically and mentally. The high volume of cases, the risk of exposure, and the emotional toll of dealing with critically ill patients can lead to significant stress and burnout. Paramedic services have implemented support systems to address mental health and well-being, including counseling services and peer support programs. Recognizing and addressing the mental health needs of paramedics is crucial for maintaining their effectiveness and resilience in the face of ongoing challenges.

Training and Adaptation to Evolving Protocols

As the COVID-19 situation evolved, so did the protocols and guidelines for paramedics. Continuous training and adaptation are essential for ensuring that paramedics are up-to-date with the latest information and best practices. This includes understanding new variants of the virus, updated PPE guidelines, and evolving treatment protocols. Ongoing education and simulation exercises help paramedics stay prepared for the dynamic nature of the pandemic and ensure that they can respond effectively to emerging challenges.

Collaboration with Other Healthcare Providers

Paramedics also work closely with other healthcare providers, including emergency department staff, hospital personnel, and public health officials. This collaboration is vital for coordinating care and ensuring that patients receive comprehensive treatment throughout their illness. By sharing information and resources, paramedics help streamline the response to COVID-19 and enhance the overall effectiveness of the healthcare system. In conclusion, paramedics have played a pivotal role in managing the COVID-19 pandemic. Their responsibilities have expanded beyond traditional emergency care to include infection control, patient transport, testing, and vaccination efforts. By adapting to the evolving demands of the pandemic and collaborating with other healthcare providers, paramedics contribute significantly to the fight against COVID-19 and the protection of public health. Their dedication and expertise are crucial in navigating the challenges of this global health crisis.

Conclusion

The COVID-19 pandemic has exerted unprecedented pressure on Emergency Medical Services (EMS) systems worldwide, leading to significant operational challenges. This review highlights the extensive disruption caused by the pandemic, particularly in terms of increased call volumes and delayed responses. As EMS systems faced surges in emergency calls, response times deteriorated, and the efficiency of service delivery was compromised. The pandemic underscored several critical issues, including the inadequacy of existing EMS infrastructure to handle sudden spikes in demand. Decreased response times and delays in ambulance dispatch were prominent concerns, leading to increased collateral mortality and morbidity among non-COVID-19 patients. These findings reveal a systemic vulnerability in EMS operations that was exacerbated by the pandemic's scale and intensity. Moreover, the study identified key factors contributing to these disruptions, including resource constraints, operational inefficiencies, and social dynamics. The high volume of COVID-19 cases not only overwhelmed EMS systems but also strained resources and altered response protocols. The increased demand for emergency services, coupled with the need for enhanced safety measures, further complicated the situation. In light of these challenges, the study advocates for the development of more robust crisis response strategies. Enhancing EMS infrastructure, optimizing resource allocation, and implementing adaptive response strategies are essential steps to improve resilience against future emergencies. The pandemic has provided valuable lessons on the importance of preparedness and flexibility in emergency response systems. Overall, this review offers critical insights into the impact of the COVID-19 pandemic on EMS operations and serves as a guide for policymakers and EMS managers to better prepare for and manage similar crises in the future. By addressing the identified issues and implementing recommended strategies, EMS systems can enhance their effectiveness and ensure timely and efficient service delivery during future emergencies.

References

1. Gondi S, Beckman AL, Deveau N, et al. Personal protective equipment needs in the USA during the COVID-19 pandemic. *Lancet*. 2020; 395(10237):e90 https://www.ncbi.nlm.nih.gov/pmc/articles/pmc7255297/.
2. WHO. Clinical Management of COVID-19: Interim Guidance, 27 May 2020. World Health Organization; 2020. https://apps.who.int/iris/bitstream/handle/10665/332196/WHO-2019-nCoV-clinical-2020.5-eng.pdf
3. Zhang X, Tan Y, Ling Y, et al. Viral and host factors related to the clinical outcome of COVID-19. *Nature*. 2020. https://doi.org/10.1038/s41586-020-2355-0.
4. Zhang L, Jackson CB, Mou H, et al. The D614G mutation in the SARS-CoV-2 spike protein reduces S1 shedding and increases infectivity. *bioRxiv*. June 2020. doi:https://doi.org/10.1101/2020.06.12.148726
5. Wang D, Hu B, Hu C, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. *JAMA*. 2020; 323: 1061. https://doi.org/10.1001/jama.2020.1585.

6. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet*. 2020; 395: 1054. https://doi.org/10.1016/S0140-6736(20)30566-3.
7. Guan W-J, Ni Z-Y, Hu Y, et al. Clinical characteristics of coronavirus disease 2019 in China. *N Engl J Med*. 2020; 382: 1708. https://doi.org/10.1056/NEJMoa2002032.
8. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 2020; 395(10223): 497-506. https://doi.org/10.1016/S0140-6736(20)30183-5.
9. Mani VR, Kalabin A, Valdivieso SC, Murray-Ramcharan M, Donaldson B. At the epicenter of the American coronavirus outbreak - New York inner city hospital COVID-19 experience and current data: a retrospective analysis. *J Med Internet Res*. 2020. https://doi.org/10.2196/20548.
10. Cecconi M, Piovani D, Brunetta E, et al. Early predictors of clinical deterioration in a cohort of 239 patients hospitalized for Covid-19 infection in Lombardy, Italy. *J Clin Med es*. 2020; 9(5): 1548. https://doi.org/10.3390/jcm9051548.
11. Chen N, Zhou M, Dong X, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet*. 2020; 395(10223): 507-513. https://doi.org/10.1016/S0140-6736(20)30211-7.
12. Zhang C, Gu J, Chen Q, et al. Clinical and epidemiological characteristics of pediatric SARS-CoV-2 infections in China: a multicenter case series. *PLoS Med*. 2020; 17(6):e1003130. https://doi.org/10.1371/journal.pmed.1003130.
13. Wu C, Chen X, Cai Y, et al. Risk factors associated with acute respiratory distress syndrome and death in patients with coronavirus disease 2019 pneumonia in Wuhan, China. *JAMA Intern Med*. 2020; 180: 934. https://doi.org/10.1001/jamainternmed.2020.0994.
14. Imam Z, Odish F, Gill I, et al. Older age and comorbidity are independent mortality predictors in a large cohort of 1305 COVID-19 patients in Michigan, United States. *J Intern Med*. 2020. https://doi.org/10.1111/joim.13119.
15. Ciceri F, Castagna A, Rovere-Querini P, et al. Early predictors of clinical outcomes of COVID-19 outbreak in Milan, Italy. *Clin Immunol*. 2020; 217:108509. https://doi.org/10.1016/j.clim.2020.108509.
16. Galloway JB, Norton S, Barker RD, et al. A clinical risk score to identify patients with COVID-19 at high risk of critical care admission or death: an observational cohort study. *J Infect*. 2020. https://doi.org/10.1016/j.jinf.2020.05.064.
17. Petrilli CM, Jones SA, Yang J, et al. Factors associated with hospital admission and critical illness among 5279 people with coronavirus disease 2019 in New York City: prospective cohort study. *BMJ*. 2020; 369:m1966. https://doi.org/10.1136/bmj.m1966.
18. Liang W, Liang H, Ou L, et al. Development and validation of a clinical risk score to predict the occurrence of critical illness in hospitalized patients with COVID-19. *JAMA Intern Med*. 2020. https://doi.org/10.1001/jamainternmed.2020.2033.
19. Duan J, Wang X, Chi J, et al. Correlation between the variables collected at admission and progression to severe cases during hospitalization among

patients with COVID-19 in Chongqing. *J Med Virol*. 2020. https://doi.org/10.1002/jmv.26082.
20. Li Q, Cao Y, Chen L, et al. Hematological features of persons with COVID-19. *Leukemia*. 2020. https://doi.org/10.1038/s41375-020-0910-1.
21. Yang X, Yu Y, Xu J, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. *Lancet Respir Med*. 2020; 8(5): 475-481. https://doi.org/10.1016/S2213-2600(20)30079-5.
22. Grasselli G, Zangrillo A, Zanella A, et al. Baseline characteristics and outcomes of 1591 patients infected with SARS-CoV-2 admitted to ICUs of the Lombardy region, Italy. *JAMA*. 2020; 323: 1574. https://doi.org/10.1001/jama.2020.5394.
23. CDC COVID-19 Response Team. Severe outcomes among patients with coronavirus disease 2019 (COVID-19) - United States, February 12-March 16, 2020. *MMWR Morb Mortal Wkly Rep*. 2020; 69(12): 343-346. https://doi.org/10.15585/mmwr.mm6912e2.
24. Palaiodimos L, Kokkinidis DG, Li W, et al. Severe obesity, increasing age and male sex are independently associated with worse in-hospital outcomes, and higher in-hospital mortality, in a cohort of patients with COVID-19 in the Bronx, New York. *Metabolism*. 2020; 108:154262. https://doi.org/10.1016/j.metabol.2020.154262.
25. Li X, Xu S, Yu M, et al. Risk factors for severity and mortality in adult COVID-19 inpatients in Wuhan. *J Allergy Clin Immunol*. 2020; 146: 110. https://doi.org/10.1016/j.jaci.2020.04.006.
26. Zhu Z, Cai T, Fan L, et al. Clinical value of immune-inflammatory parameters to assess the severity of coronavirus disease 2019. *Int J Infect Dis*. 2020; 95: 332-339. https://doi.org/10.1016/j.ijid.2020.04.041.
27. Price-Haywood EG, Burton J, Fort D, Seoane L. Hospitalization and mortality among black patients and white patients with Covid-19. *N Engl J Med*. 2020; 382: 2534. https://doi.org/10.1056/NEJMsa2011686.
28. Chen T, Wu D, Chen H, et al. Clinical characteristics of 113 deceased patients with coronavirus disease 2019: retrospective study. *BMJ*. 2020; 368:m1091. https://doi.org/10.1136/bmj.m1091.
29. Huang S, Wang J, Liu F, et al. COVID-19 patients with hypertension have more severe disease: a multicenter retrospective observational study. *Hypertens Res*. 2020. https://doi.org/10.1038/s41440-020-0485-2.
30. Guo W, Li M, Dong Y, et al. Diabetes is a risk factor for the progression and prognosis of COVID-19. *Diabetes Metab Res Rev*. 2020;e3319. https://doi.org/10.1002/dmrr.3319.
31. CDC. Coronavirus Disease 2019 (COVID-19). Centers for Disease Control and Prevention. https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-with-medical-conditions.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fneed-extra-precautions%2Fgroups-at-higher-risk.html. Published June 25, 2020. Accessed June 27, 2020.
32. Hernández-Garduño E. Obesity is the comorbidity more strongly associated for Covid-19 in Mexico. A case-control study. *Obes Res Clin Pract*. 2020. https://doi.org/10.1016/j.orcp.2020.06.001.

33. Wang Z, Du Z, Zhu F. Glycosylated hemoglobin is associated with systemic inflammation, hypercoagulability, and prognosis of COVID-19 patients. *Diabetes Res Clin Pract*. 2020; 164:108214. https://doi.org/10.1016/j.diabres.2020.108214.
34. Mullen B. COVID-19 Clinical Guidance For the Cardiovascular Care Team. American College of Cardiology. https://www.acc.org//~/media/Non-Clinical/Files-PDFs-Excel-MS-Word-etc/2020/02/S20028-ACC-Clinical-Bulletin-Coronavirus.pdf. Published June 20, 2003. Accessed May 20, 2004.
35. Liang W, Guan W, Chen R, et al. Cancer patients in SARS-CoV-2 infection: a nationwide analysis in China. *Lancet Oncol*. 2020; 21(3): 335-337. https://doi.org/10.1016/S1470-2045(20)30096-6.
36. Zhang L, Zhu F, Xie L, et al. Clinical characteristics of COVID-19-infected cancer patients: a retrospective case study in three hospitals within Wuhan, China. *Ann Oncol*. 2020; 31(7): 894-901. https://doi.org/10.1016/j.annonc.2020.03.296.
37. Tian J, Yuan X, Xiao J, et al. Clinical characteristics and risk factors associated with COVID-19 disease severity in patients with cancer in Wuhan, China: a multicentre, retrospective, cohort study. *Lancet Oncol*. 2020; 21: 893. https://doi.org/10.1016/S1470-2045(20)30309-0.
38. Kuderer NM, Choueiri TK, Shah DP, et al. Clinical impact of COVID-19 on patients with cancer (CCC19): a cohort study. *Lancet*. 2020; 395(10241): 1907-1918. https://doi.org/10.1016/S0140-6736(20)31187-9.
39. Mehta V, Goel S, Kabarriti R, et al. Case fatality rate of cancer patients with COVID-19 in a New York hospital system. *Cancer Discov*. 2020; 10: 935. https://doi.org/10.1158/2159-8290.CD-20-0516.
40. Lee LYW, Cazier JB, Starkey T, et al. COVID-19 mortality in patients with cancer on chemotherapy or other anticancer treatments: a prospective cohort study. *Lancet*. 2020; 395(10241): 1919-1926. https://doi.org/10.1016/S0140-6736(20)31173-9.
41. Pereira MR, Mohan S, Cohen DJ, et al. COVID-19 in solid organ transplant recipients: initial report from the US epicenter. *Am J Transplant*. 2020; 20: 1800. https://doi.org/10.1111/ajt.15941.
42. Zhou Y, He Y, Yang H, et al. Development and validation a nomogram for predicting the risk of severe COVID-19: a multi-center study in Sichuan, China. *PLoS One*. 2020; 15(5):e0233328. https://doi.org/10.1371/journal.pone.0233328.
43. Xie J, Covassin N, Fan Z, et al. Association between hypoxemia and mortality in patients with COVID-19. *Mayo Clin Proc*. 2020; 95(6): 1138-1147. https://doi.org/10.1016/j.mayocp.2020.04.006.
44. Rubin GD, Ryerson CJ, Haramati LB, et al. The role of chest imaging in patient management during the COVID-19 pandemic: a multinational consensus statement from the Fleischner society. *Radiology*. 2020; 296: 172. https://doi.org/10.1148/radiol.2020201365.
45. Wong HYF, Lam HYS, Fong AH-T, et al. Frequency and distribution of chest radiographic findings in COVID-19 positive patients. *Radiology*. 2019;201160. https://doi.org/10.1148/radiol.2020201160.

46. Chung M, Bernheim A, Mei X, et al. CT imaging features of 2019 novel coronavirus (2019-nCoV). *Radiology*. 2020; 295(1): 202-207. https://doi.org/10.1148/radiol.2020200230.
47. Lei DP. The progression of computed tomographic (CT) images in patients with coronavirus disease (COVID-19) pneumonia: the CT progression of COVID-19 pneumonia. *J Infect*. 2020; 80:e30. https://doi.org/10.1016/j.jinf.2020.03.020.
48. Yuan M, Yin W, Tao Z, Tan W, Hu Y. Association of radiologic findings with mortality of patients infected with 2019 novel coronavirus in Wuhan, China. *PLoS One*. 2020; 15(3):e0230548. https://doi.org/10.1371/journal.pone.0230548.
49. American College of Radiology. Illustrated breast imaging reporting and data system (BI-RADS). American College of Radiology. 2003. https://ci.nii.ac.jp/naid/10014560841/. Accessed April 15, 2020.
50. Shi H, Han X, Jiang N, et al. Radiological findings from 81 patients with COVID-19 pneumonia in Wuhan, China: a descriptive study. *Lancet Infect Dis*. 2020; 20(4): 425-434. https://doi.org/10.1016/S1473-3099(20)30086-4.
51. Spagnolo P, Cozzi A, Foà RA, et al. CT-derived pulmonary vascular metrics and clinical outcome in COVID-19 patients. *Quant Imaging Med Surg*. 2020; 10(6): 1325-1333. https://doi.org/10.21037/qims-20-546.
52. Borghesi A, Zigliani A, Golemi S, et al. Chest X-ray severity index as a predictor of in-hospital mortality in coronavirus disease 2019: a study of 302 patients from Italy. *Int J Infect Dis*. 2020; 96: 291-293. https://doi.org/10.1016/j.ijid.2020.05.021.
53. Henry BM, de Oliveira MHS, Benoit S, Plebani M, Lippi G. Hematologic, biochemical and immune biomarker abnormalities associated with severe illness and mortality in coronavirus disease 2019 (COVID-19): a meta-analysis. *Clin Chem Lab Med*. 2020; 58(7): 1021-1028. https://doi.org/10.1515/cclm-2020-0369.
54. Jose RJ, Manuel A. COVID-19 cytokine storm: the interplay between inflammation and coagulation. *Lancet Respir Med*. 2020; 8:e46. https://doi.org/10.1016/S2213-2600(20)30216-2.
55. Shang W, Dong J, Ren Y, et al. The value of clinical parameters in predicting the severity of COVID-19. *J Med Virol*. 2020. https://doi.org/10.1002/jmv.26031.
56. Hu L, Chen S, Fu Y, et al. Risk factors associated with clinical outcomes in 323 COVID-19 hospitalized patients in Wuhan, China. *Clin Infect Dis*. 2020. https://doi.org/10.1093/cid/ciaa539.
57. Cummings MJ, Baldwin MR, Abrams D, et al. Epidemiology, clinical course, and outcomes of critically ill adults with COVID-19 in New York City: a prospective cohort study. *Lancet*. 2020; 395(10239): 1763-1770. https://doi.org/10.1016/S0140-6736(20)31189-2.
58. Oxley TJ, Mocco J, Majidi S, et al. Large-vessel stroke as a presenting feature of Covid-19 in the young. *N Engl J Med*. 2020; 382:e60. https://doi.org/10.1056/NEJMc2009787.
59. Xiong W, Mu J, Guo J, et al. New onset neurologic events in people with COVID-19 infection in three regions in China. *Neurology*. 2020. https://doi.org/10.1212/WNL.0000000000010034.

60. Tang N, Li D, Wang X, Sun Z. Abnormal coagulation parameters are associated with poor prognosis in patients with novel coronavirus pneumonia. *J Thromb Haemost*. 2020; 18(4): 844-847. https://doi.org/10.1111/jth.14768.
61. Li C, Hu B, Zhang Z, et al. D-dimer triage for COVID-19. *Acad Emerg Med*. 2020. https://doi.org/10.1111/acem.14037.
62. Zhang L, Yan X, Fan Q, et al. D-dimer levels on admission to predict in-hospital mortality in patients with Covid-19. *J Thromb Haemost*. 2020; 18(6): 1324-1329. https://doi.org/10.1111/jth.14859.
63. Levi M, Thachil J, Iba T, Levy JH. Coagulation abnormalities and thrombosis in patients with COVID-19. *Lancet Haematol*. 2020; 7(6):e438-e440. https://doi.org/10.1016/S2352-3026(20)30145-9.
64. Gao Y, Li T, Han M, et al. Diagnostic utility of clinical laboratory data determinations for patients with the severe COVID-19. *J Med Virol*. 2020; 92(7): 791-796. https://doi.org/10.1002/jmv.25770.
65. Chen R, Sang L, Jiang M, et al. Longitudinal hematologic and immunologic variations associated with the progression of COVID-19 patients in China. *J Allergy Clin Immunol*. 2020; 146: 89. https://doi.org/10.1016/j.jaci.2020.05.003.
66. Spiezia L, Boscolo A, Poletto F, et al. COVID-19-related severe hypercoagulability in patients admitted to intensive care unit for acute respiratory failure. *Thromb Haemost*. 2020; 120(6): 998-1000. https://doi.org/10.1055/s-0040-1710018.
67. Chibane S, Gibeau G, Poulin F, et al. Hyperacute multi-organ thromboembolic storm in COVID-19: a case report. *J Thromb Thrombolysis*. 2020. https://doi.org/10.1007/s11239-020-02173-w.
68. Yaghi S, Ishida K, Torres J, et al. SARS-CoV-2 and stroke in a New York healthcare system. *Stroke*. 2020; 51(7): 2002-
69. Pavoni V, Gianesello L, Pazzi M, Stera C, Meconi T, Frigieri FC. Evaluation of coagulation function by rotation thromboelastometry in critically ill patients with severe COVID-19 pneumonia. *J Thromb Thrombolysis*. 2020. https://doi.org/10.1007/s11239-020-02130-7.
70. Tabatabai A, Rabin J, Menaker J, et al. Factor VIII and functional protein C activity in critically ill patients with coronavirus disease 2019: a case series. *A A Pract*. 2020; 14(7):e01236. https://doi.org/10.1213/XAA.0000000000001236.
71. Escher R, Breakey N, Lämmle B. Severe COVID-19 infection associated with endothelial activation. *Thromb Res*. 2020; 190: 62. https://doi.org/10.1016/j.thromres.2020.04.014.
72. Varga Z, Flammer AJ, Steiger P, et al. Endothelial cell infection and endotheliitis in COVID-19. *Lancet*. 2020; 395(10234): 1417-1418. https://doi.org/10.1016/S0140-6736(20)30937-5.
73. Yao XH, Li TY, He ZC, et al. A pathological report of three COVID-19 cases by minimally invasive autopsies. *Zhonghua Bing Li Xue Za Zhi*. 2020; 49(0):E009. https://doi.org/10.3760/cma.j.cn112151-20200312-00193.
74. Inciardi RM, Lupi L, Zaccone G, et al. Cardiac involvement in a patient with coronavirus disease 2019 (COVID-19). *JAMA Cardiol*. 2020. https://doi.org/10.1001/jamacardio.2020.1096.

75. Liu Y, Yang Y, Zhang C, et al. Clinical and biochemical indexes from 2019-nCoV infected patients linked to viral loads and lung injury. *Sci China Life Sci.* 2020; 63(3): 364-374. https://doi.org/10.1007/s11427-020-1643-8.
76. Chen C, Zhou Y, Wang DW. SARS-CoV-2: a potential novel etiology of fulminant myocarditis. *Herz.* 2020; 45: 230. https://doi.org/10.1007/s00059-020-04909-z.
77. Escher F, Pietsch H, Aleshcheva G, et al. Detection of viral SARS-CoV-2 genomes and histopathological changes in endomyocardial biopsies. *ESC Heart Fail.* 2020. https://doi.org/10.1002/ehf2.12805.
78. Bangalore S, Sharma A, Slotwiner A, et al. ST-segment elevation in patients with Covid-19—a case series. *N Engl J Med.* 2020; 382: 2478. https://doi.org/10.1056/nejmc2009020.
79. Rath D, Petersen-Uribe Á, Avdiu A, et al. Impaired cardiac function is associated with mortality in patients with acute COVID-19 infection. *Clin Res Cardiol.* 2020. https://doi.org/10.1007/s00392-020-01683-0.
80. Shi S, Qin M, Shen B, et al. Association of cardiac injury with mortality in hospitalized patients with COVID-19 in Wuhan, China. *JAMA Cardiol.* 2020. https://doi.org/10.1001/jamacardio.2020.0950.
81. Guo T, Fan Y, Chen M, et al. Cardiovascular implications of fatal outcomes of patients with coronavirus disease 2019 (COVID-19). *JAMA Cardiol.* 2020. https://doi.org/10.1001/jamacardio.2020.1017.
82. Cao Z, Li T, Liang L, et al. Clinical characteristics of coronavirus disease 2019 patients in Beijing, China. *PLoS One.* 2020; 15(6):e0234764. https://doi.org/10.1371/journal.pone.0234764.
83. Franks CE, Scott MG, Farnsworth CW. Elevated cardiac troponin I is associated with poor outcomes in COVID-19 patients at an academic medical center in Midwestern USA. *J Appl Lab Med.* 2020. https://doi.org/10.1093/jalm/jfaa092.
84. Vrsalovic M, Vrsalovic PA. Cardiac troponins predict mortality in patients with COVID-19: a meta-analysis of adjusted risk estimates. *J Infect.* 2020. https://doi.org/10.1016/j.jinf.2020.05.022.
85. Shi S, Qin M, Cai Y, et al. Characteristics and clinical significance of myocardial injury in patients with severe coronavirus disease 2019. *Eur Heart J.* 2020; 41(22): 2070-2079. https://doi.org/10.1093/eurheartj/ehaa408.
86. Toraih EA, Elshazli RM, Hussein MH, et al. Association of cardiac biomarkers and comorbidities with increased mortality, severity, and cardiac injury in COVID-19 patients: a meta-regression and Decision tree analysis. *J Med Virol.* 2020. https://doi.org/10.1002/jmv.26166.
87. Zheng H-Y, Zhang M, Yang C-X, et al. Elevated exhaustion levels and reduced functional diversity of T cells in peripheral blood may predict severe progression in COVID-19 patients. *Cell Mol Immunol.* 2020; 17(5): 541-543. https://doi.org/10.1038/s41423-020-0401-3.
88. Ma A, Cheng J, Yang J, Dong M, Liao X, Kang Y. Neutrophil-to-lymphocyte ratio as a predictive biomarker for moderate-severe ARDS in severe COVID-19 patients. *Crit Care.* 2020; 24(1): 288. https://doi.org/10.1186/s13054-020-03007-0.
89. Tan L, Wang Q, Zhang D, Ding J, Miao H. Lymphopenia predicts disease severity of COVID-19: a descriptive and predictive study. March 2020. doi:https://doi.org/10.1101/2020.03.01.20029074

90. Tan C, Huang Y, Shi F, et al. C-reactive protein correlates with computed tomographic findings and predicts severe COVID-19 early. *J Med Virol*. 2020; 92(7): 856-862. https://doi.org/10.1002/jmv.25871.
91. Huang W, Berube J, McNamara M, et al. Lymphocyte subset counts in COVID-19 patients: a meta-analysis. *Cytometry A*. 2020. https://doi.org/10.1002/cyto.a.24172.
92. Jiang M, Guo Y, Luo Q, et al. T cell subset counts in peripheral blood can be used as discriminatory biomarkers for diagnosis and severity prediction of COVID-19. *J Infect Dis*. 2020; 222: 198. https://doi.org/10.1093/infdis/jiaa252.
93. Liu Z, Long W, Tu M, et al. Lymphocyte subset (CD4+, CD8+) counts reflect the severity of infection and predict the clinical outcomes in patients with COVID-19. *J Infect*. 2020. https://doi.org/10.1016/j.jinf.2020.03.054.
94. S, Jiang L, Li X, et al. Clinical and pathological investigation of patients with severe COVID-19. *JCI Insight*. 2020; 5(12). https://doi.org/10.1172/jci.insight.138070.
95. Xie G, Ding F, Han L, Yin D, Lu H, Zhang M. The role of peripheral blood eosinophil counts in COVID-19 patients. *Allergy*. 2020. https://doi.org/10.1111/all.14465.
96. Yao N, Wang SN, Lian JQ, et al. Clinical characteristics and influencing factors of patients with novel coronavirus pneumonia combined with liver injury in Shaanxi region. *Zhonghua Gan Zang Bing Za Zhi*. 2020; 28:E003. https://doi.org/10.3760/cma.j.cn501113-20200226-00070.
97. Piano S, Dalbeni A, Vettore E, et al. Abnormal liver function tests predict transfer to intensive care unit and death in COVID-19. *Liver Int*. 2020. https://doi.org/10.1111/liv.14565.
98. Goldwasser P, Feldman J. Association of serum albumin and mortality risk. *J Clin Epidemiol*. 1997; 50(6): 693-703. https://doi.org/10.1016/s0895-4356(97)00015-2.
99. J, Cheng A, Kumar R, et al. Hypoalbuminemia predicts the outcome of COVID-19 independent of age and co-morbidity. *J Med Virol*. 2020. https://doi.org/10.1002/jmv.26003.
100. Bi X, Su Z, Yan H, et al. Prediction of severe illness due to COVID-19 based on an analysis of initial fibrinogen to albumin ratio and platelet count. *Platelets*. 2020; 31: 674-679. https://doi.org/10.1080/09537104.2020.1760230.
101. Herlekar R, Roy AS, Matson M. Hypoalbuminaemia in COVID-19 infection: a predictor of severity or a potential therapeutic target? *J Med Virol*. 2020. https://doi.org/10.1002/jmv.26151.
102. Ibáñez-Samaniego L, Bighelli F, Usón C, et al. Elevation of liver fibrosis index FIB-4 is associated with poor clinical outcomes in patients with COVID-19. *J Infect Dis*. 2020. https://doi.org/10.1093/infdis/jiaa355.
103. Zhou B, She J, Wang Y, Ma X. The clinical characteristics of myocardial injury 1 in severe and very severe patients with 2019 novel coronavirus disease. *J Infect*. 2020; 81: 147. https://doi.org/10.1016/j.jinf.2020.03.021.
104. Poggiali E, Zaino D, Immovilli P, et al. Lactate dehydrogenase and C-reactive protein as predictors of respiratory failure in CoVID-19 patients. *Clin Chim Acta*. 2020; 509: 135-138. https://doi.org/10.1016/j.cca.2020.06.012.

105. Zhang G, Zhang J, Wang B, Zhu X, Wang Q, Qiu S. Analysis of clinical characteristics and laboratory findings of 95 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a retrospective analysis. *Respir Res*. 2020; 21(1): 74. https://doi.org/10.1186/s12931-020-01338-8.
106. Cheng Y, Luo R, Wang K, et al. Kidney disease is associated with in-hospital death of patients with COVID-19. *Kidney Int*. 2020; 97(5): 829-838. https://doi.org/10.1016/j.kint.2020.03.005.
107. Wang G, Wu C, Zhang Q, et al. C-reactive protein level may predict the risk of COVID-19 aggravation. *Open Forum Infect Dis*. 2020; 7(5):ofaa153. https://doi.org/10.1093/ofid/ofaa153.
108. Yan L, Zhang H-T, Xiao Y, et al. Prediction of criticality in patients with severe Covid-19 infection using three clinical features: a machine learning-based prognostic model with clinical data in Wuhan. *medRxiv*. 2020. https://www.medrxiv.org/content/10.1101/2020.02.27.20028027v2.full.pdf
109. Liu F, Li L, Xu M, et al. Prognostic value of interleukin-6, C-reactive protein, and procalcitonin in patients with COVID-19. *J Clin Virol*. 2020; 127:104370. https://doi.org/10.1016/j.jcv.2020.104370.
110. Luo X, Zhou W, Yan X, et al. Prognostic value of C-reactive protein in patients with COVID-19. *Clin Infect Dis*. 2020. https://doi.org/10.1093/cid/ciaa641.
111. C, Demirkol MA, Altunok ES, et al. Performance of pneumonia severity index and CURB-65 in predicting 30-day mortality in patients with COVID-19. *Int J Infect Dis*. 2020. https://doi.org/10.1016/j.ijid.2020.06.038.
112. Han H, Ma Q, Li C, et al. Profiling serum cytokines in COVID-19 patients reveals IL-6 and IL-10 are disease severity predictors. *Emerg Microbes Infect*. 2020; 9(1): 1123-1130. https://doi.org/10.1080/22221751.2020.1770129.
113. Zhao Y, Qin L, Zhang P, et al. Longitudinal COVID-19 profiling associates IL-1Ra and IL-10 with disease severity and RANTES with mild disease. *JCI Insight*. 2020. https://doi.org/10.1172/jci.insight.139834.
114. Gallo Marin, B., Aghagoli, G., Lavine, K., Yang, L., Siff, E. J., Chiang, S. S., ... & Michelow, I. C. (2021). Predictors of COVID-19 severity: a literature review. *Reviews in medical virology*, *31*(1), 1-10.

المسعف وجائحة COVID-19: مقال مراجعة

الملخص:

الخلفية :لقد اجتاحت جائحة COVID-19 خدمات الطوارئ الطبية (EMS) في جميع أنحاء العالم، مما أدى إلى زيادة حجم المكالمات، والتأخيرات، واضطرابات في تقديم الخدمة. تستكشف هذه الدراسة تأثير الجائحة على عمليات EMS وتحدد العوامل الرئيسية التي تسهم في هذه التحديات.

الهدف :الهدف هو تحليل الاضطرابات في خدمات EMS التي سببتها جائحةCOVID-19 ، وفحص العوامل المختلفة التي أثرت على أوقات الاستجابة، وجودة الخدمة، وكفاءة EMS العامة خلال ذروة الأزمة.

الطرق :تم استخدام منهجية المراجعة السردية لتلخيص النتائج من الأدبيات الحالية حول استجابة EMS خلال جائحة COVID-19. تم تصنيف العوامل التي تؤثر على عمليات EMS إلى ثلاث مجموعات رئيسية: العوامل المتعلقة بـEMS ، الديناميات الاجتماعية، والعوامل المتعلقة بالمرضى. ركزت المراجعة على تحليل تأثيرات هذه العوامل على مكالماتEMS ، وأوقات الاستجابة، وتقديم الخدمة العامة.

النتائج :حددت الدراسة خمسة مواضيع رئيسية تؤثر على EMS خلال الجائحة: (1) زيادة حجم مكالماتEMS ، (2)انخفاض أوقات الاستجابة، (3) تأخيرات في إرسال سيارات الإسعاف، (4) زيادة الوفيات والأمراض الجانبية بين الحالات غير المتعلقة بـCOVID-19 ، و(5) زيادة الوقت الإجمالي لمكالمات الإسعاف. نسبّت هذه الاضطرابات إلى مزيج من حجم المكالمات المرتفع، قيود الموارد، والتحديات التشغيلية التي تفاقمت بسبب الجائحة.

الخلاصة :أثرت جائحة COVID-19 بشكل كبير على عمليات EMS على مستوى العالم، مما يبرز الحاجة إلى تحسين استراتيجيات الاستجابة للأزمات. تسلط النتائج الضوء على أهمية تعزيز بنية EMS التحتية، وتحسين تخصيص الموارد، وتنفيذ استراتيجيات تكيفية لإدارة أحجام المكالمات المرتفعة وضمان الاستجابات في الوقت المناسب خلال الطوارئ المستقبلية.

الكلمات المفتاحية :COVID-19، خدمات الطوارئ الطبية، استجابةEMS ، تأثير الجائحة، اضطرابات الخدمة، إدارة الأزمات.