

ORIGINAL RESEARCH



Prehospital management of hypertension by emergency medical teams during the COVID-19 pandemic: a retrospective analysis

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Abstract

Hypertension is frequently managed by emergency medical teams (EMTs), presenting a significant challenge for emergency medical services (EMS). The COVID-19 pandemic added complexities to EMS operations, especially in the prehospital management of hypertensive emergencies. This study evaluates the prehospital management of primary hypertension by EMTs, focusing on therapeutic actions, transport decisions, and outcomes during the COVID-19 pandemic, with the goal of identifying factors influencing EMT decision-making and optimizing EMS resource allocation. A retrospective analysis was conducted on medical records from the Bieszczady EMS operational area from April 2019 to June 2021. Data from Dispatch Order Cards and Medical Rescue Activity Cards were analyzed for 2002 cases of prehospital primary hypertension. Statistical analyses included normality tests, independent samples *t*-test, Pearson's Chi-squared test, and Two-way Analysis of Variance (ANOVA), with a significance level set at $p < 0.05$. EMT interventions were significantly longer for patients transported to the emergency department (ED) compared to those managed on-scene ($t = -22.563, p < 0.001$). Patients transported to the ED showed higher systolic and diastolic blood pressure (SBP: $t = -20.366, p < 0.001$; DBP: $t = -13.718, p < 0.001$). EMTs administered more medications on-scene, suggesting effective pharmacological intervention reduced the need for hospital transport ($t = 11.951, p < 0.001$). Additionally, patients managed on-scene experienced a greater reduction in mean arterial pressure ($t = 7.707, p < 0.001$). These findings highlight the need to enhance EMT training, medication protocols, and triage strategies to improve patient outcomes and EMS resource allocation, especially during public health emergencies. Further research should explore the long-term effects of prehospital hypertension management on EMS systems.

Keywords

Hypertension; Emergency medical teams; Prehospital management; COVID-19; Emergency department; Blood pressure; Pharmacological interventions; Response time; Mean arterial pressure; Retrospective analysis

1. Introduction

Hypertension is among the most frequently diagnosed conditions by Emergency Medical Teams (EMT), highlighting the significant burden it places on emergency medical services (EMS) [1]. This high incidence underscores the critical role EMTs play in managing hypertensive crises, which, if left untreated, can lead to severe complications such as stroke, myocardial infarction, and organ damage [2]. The prompt and effective management of hypertensive emergencies by EMT members is crucial for delivering efficient and timely care to patients, ensuring favorable outcomes, and minimizing long-term health risks.

However, not all cases of hypertension require immediate intervention by EMS. Often, these conditions can be managed more appropriately by primary care physicians [3, 4]. Misallocation of EMS resources to non-emergency hypertensive cases can delay critical care for other patients in need of urgent medical attention, exacerbating the strain on already limited EMS resources [5]. This issue is particularly pressing in rural and underserved areas, where the availability of EMTs is constrained. Inappropriate use of EMS for non-emergency hypertensive cases not only impacts patient care but also affects the overall efficiency of the healthcare system.

Previous studies have emphasized the importance of prehospital management of hypertensive emergencies and the role

of EMTs in ensuring optimal patient outcomes. For instance, research by Patrick *et al.* [6] demonstrated that effective prehospital care could significantly reduce the incidence of adverse cardiovascular events in patients with hypertensive emergencies. Furthermore, a study by Świeżewski *et al.* [7] highlighted the challenges faced by EMTs in rural areas, where resource constraints often lead to delays in providing necessary medical interventions.

The ongoing COVID-19 pandemic has added complexity to the healthcare landscape, affecting how medical services are delivered and utilized [8]. EMTs are now faced with additional challenges in managing hypertensive emergencies while adhering to pandemic-related protocols, such as personal protective equipment (PPE) usage, social distancing and infection control measures [9]. These protocols can extend the duration of interventions and affect decision-making processes. The pandemic has also altered patient behavior, with many individuals avoiding healthcare facilities due to fear of infection, potentially leading to delays in seeking care and more severe presentations of hypertension when EMS is finally called [10]. Studies such as those by Hadian *et al.* [11] and Hick *et al.* [12] have documented the increased burden on EMS during the pandemic, with longer response times and more complex decision-making processes due to these additional challenges.

Recent literature also points to the effectiveness of specific pharmacological interventions in prehospital care. A study by Raina *et al.* [13] found that the use of combination therapies, including captopril, furosemide and hydroxyzine, could stabilize patients sufficiently to reduce the need for hospital transport. This approach aligns with findings from earlier research, such as that by Kim *et al.* [14], which recommended comprehensive medication protocols for EMTs to manage hypertensive crises effectively.

Moreover, the pandemic has spurred the need to reassess the protocols and guidelines governing EMT responses to hypertensive emergencies. The increased strain on EMS systems during the pandemic has led to discussions about the sustainability of current practices and the potential for integrating new technologies and telemedicine into prehospital care [15]. Studies have suggested that telemedicine could play a crucial role in guiding EMTs through complex decision-making processes in real time, potentially reducing the need for hospital transport and optimizing resource allocation [16]. Additionally, the integration of artificial intelligence in prehospital settings is being explored as a means to enhance the accuracy of EMT assessments and treatment decisions [17].

Understanding the therapeutic actions and decisions made by EMTs during this period can offer valuable insights into improving emergency medical responses and resource allocation. Analyzing the patterns and outcomes of EMT interventions for hypertension during the pandemic can help identify gaps in care, inform training programs, and develop guidelines that optimize the use of EMS resources. This knowledge is essential for preparing EMTs to handle not only the current pandemic but also future public health emergencies that may disrupt healthcare delivery.

The aim of this study is to analyze the decision-making processes of EMTs in managing prehospital primary hyper-

tension and to determine the factors influencing these decisions. By examining the treatment patterns and outcomes, we seek to identify strategies that can enhance the efficiency and effectiveness of EMS in handling hypertensive emergencies, particularly in the context of the ongoing COVID-19 pandemic. Through this analysis, we hope to contribute to the development of best practices for managing hypertensive patients in emergency settings, ultimately improving patient care and optimizing the use of EMS resources.

2. Materials and methods

2.1 Study design

This research was conducted within the operational zone of the Bieszczady EMS in southeastern Poland, covering the Bieszczady region. The study period spanned from 01 April 2019, to 30 June 2021, encompassing both the pre-pandemic period and the period during the COVID-19 pandemic. The first case of COVID-19 in Poland was confirmed on 04 March 2020, and the government declared a national state of epidemic on 20 March 2020. This declaration marked the beginning of significant public health measures, including those affecting emergency medical services.

The study was structured as a retrospective analysis of medical records, specifically examining Dispatch Order Cards and Medical Rescue Activity Cards completed by EMTs. In total, 2002 cases of prehospital primary hypertension identified by EMTs during emergency interventions in the Bieszczady region were included in the study.

The Dispatch Order Cards (DOCs) are standardized forms used by EMS dispatch centers to record details of emergency calls, including the nature of the emergency, the priority level assigned, and the resources dispatched. The MRACs are detailed records maintained by EMTs during their interventions, documenting patient assessments, vital signs, treatments administered, and decisions regarding patient transport.

By analyzing this data, we aimed to assess the impact of EMT decisions on patient outcomes and resource utilization. Specifically, the study explored how the choice of pharmacological interventions and transport decisions evolved during the pandemic, and the implications of these changes for emergency medical services. Additionally, the study examined the demographic characteristics of the patients and the types of medications used to manage hypertension, providing a comprehensive overview of prehospital hypertension management.

In Poland, EMTs are highly trained healthcare professionals whose competencies are defined by national legislation. They are authorized to perform a variety of medical interventions, including advanced life support, airway management, defibrillation and the administration of medications. EMTs can provide prehospital care independently or under medical supervision, depending on the severity of the patient's condition and the complexity of the required interventions.

Polish EMTs are equipped to manage emergencies such as trauma, cardiac arrest and medical conditions like hypertension. Their training includes pharmacology, the use of diagnostic tools, and the ability to assess and stabilize patients in prehospital settings. The scope of EMT competencies in

Poland allows them to administer medications like captopril, furosemide and hydroxyzine, which are commonly used in managing hypertensive emergencies, as was relevant in this study. Additionally, they are trained to make transport decisions, determining whether patients should be stabilized at the scene or transported to a hospital for further treatment.

2.2 Data collection

The data collection process involved a thorough retrospective review of DOCs and MRACs filled out by EMT personnel during their emergency responses. Each record included comprehensive details on the medical services rendered, therapeutic actions undertaken, and decisions made by the EMTs. Blood pressure readings, including systolic blood pressure (SBP) and diastolic blood pressure (DBP), were recorded using automatic non-invasive blood pressure (NIBP) monitors (manufacturer: Omron, Omron Corporation, HBP-1120 or HBP-1320 professional upper arm monitor, Kyoto, Japan) during interventions. To ensure the accuracy and reliability of the data, all documentation underwent meticulous scrutiny before inclusion in the study. This verification process was essential to maintain the study's overall integrity. For reader clarity, sample DOC and MRAC forms have been enclosed in the appendix to provide a visual reference for the types of data collected.

2.3 Selection criteria for study participation

The study focused on adult patients (18 years and older) diagnosed with primary hypertension International Classification of Diseases, 10th Revision (ICD-10: I10) by EMT members. Inclusion criteria required that emergency interventions occurred within the designated study period and that medical records contained at least one NIBP measurement. Cases involving minors, individuals with an SBP below 140 mmHg, and those with incomplete medical records were excluded from the study. Patients with an SBP above 140 mmHg who did not receive medication were included in the analysis, as their cases were reviewed based on the EMT's clinical decision-making, which considered the patient's overall stabilization and any contraindications for medication administration.

The exclusion criteria were chosen to ensure the accuracy and relevance of the study's findings. Excluding minors and individuals with SBP below 140 mmHg helped maintain a focus on significant hypertensive cases requiring EMT intervention. This selection process may limit the generalizability of the results to the broader population, particularly younger patients and those with milder hypertension. However, it enhances the study's applicability to EMT-managed hypertensive emergencies, ensuring that the findings are relevant to the target population of EMS providers.

2.4 Used variable

The study analyzed various variables related to emergency calls for hypertension during the COVID-19 pandemic, including demographic information such as the age and gender of the patients, and blood pressure measurements, including both SBP and DBP recorded during EMT interventions. These

variables included demographic information such as the age and gender of the patients, and blood pressure measurements, including both SBP and DBP recorded during EMT interventions. The study also looked at pharmacological interventions, focusing on the use of specific medications like captopril, furosemide and hydroxyzine. These three medications were chosen based on their widespread use and availability within the Bieszczady EMS operational area during the study period. Although other medications, such as urapidil and nitroglycerin, are also available to Polish paramedics for blood pressure reduction, they were not included in this study. Their exclusion may be due to regional EMS protocols, limited availability, or changes in standards of care during the pandemic. Future research could explore the impact of these alternative medications in prehospital hypertension management.

Additionally, the study analyzed transport decisions made by EMTs, determining whether patients were taken to the emergency department or left at the scene.

The dependent variables in this study were the transport decision (whether the patient was taken to the ED or left at the scene) and the change in blood pressure (measured as the difference between initial and final SBP/DBP readings). Independent variables included patient demographics (age, gender), the type of pharmacological intervention used, and the duration of the EMT intervention.

2.5 Data management and security

All data were securely stored in systems with restricted access to ensure confidentiality and data integrity. Only authorized personnel had access to the data, which were used solely for scientific purposes. Data management protocols adhered to strict guidelines to protect patient privacy and ensure compliance with ethical standards.

2.6 Study outcomes

The primary outcomes of this study focused on evaluating the effectiveness and efficiency of prehospital management of primary hypertension by EMTs. One of the key outcomes measured was the duration from the time the emergency call was received to the arrival of the EMT at the scene, assessing the response time of the EMS. Another important outcome was the duration from the EMT's arrival at the scene to the completion of all medical interventions, which included administering medications, performing necessary procedures, and making transport decisions. Additionally, the total time from receiving the emergency call to the completion of the intervention, encompassing the entire EMS response and on-scene management, was measured to evaluate overall efficiency.

The scope of the intervention covered all medical actions taken by the EMTs, such as administering medications like captopril, furosemide and hydroxyzine, monitoring the patient's vital signs, and deciding whether the patient required transport to the ED. The intervention also included the stabilization of the patient on-site, with the potential outcome of the patient being left at the scene if the EMTs determined it was safe to do so. Another critical outcome was the decision regarding patient transport, where the severity of the patient's

condition guided the EMTs in deciding whether further medical evaluation at a hospital was necessary.

Blood pressure management was a significant aspect of the study, with outcomes including the initial BP measurement taken upon the EMT's arrival at the scene and the control BP measurement recorded after the intervention. The EMTs monitored the changes in BP to assess the effectiveness of the interventions. The study also examined the change in mean arterial pressure from the initial to the control measurement, providing insights into the impact of the EMTs' interventions on patient stabilization. All these outcomes collectively contributed to a comprehensive understanding of the prehospital management of hypertension by EMTs during the study period.

2.7 Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics version 29.0.0 (IBM Corporation, Armonk, NY, USA). Before conducting the main analyses, normality tests (*e.g.*, Shapiro-Wilk test) were performed on all continuous variables to confirm whether they followed a normal distribution. This step was crucial for determining the appropriate statistical tests to use. For normally distributed variables, the independent samples *t*-test was applied to compare means between two independent groups, such as SBP and DBP values for patients transported to the ED versus those left at the scene. In cases where variables did not meet normality assumptions, non-parametric tests (*e.g.*, Mann-Whitney U test) were considered. Pearson's Chi-squared test was used for analyzing categorical variables, such as the relationship between medication combinations and EMT decisions. This test determines if there is a significant association between the categories of the variables. Two-way ANOVA was utilized to analyze the effect of two independent variables on a continuous dependent variable, structured in a 2 × 2 scheme. To further explore significant interactions found in the ANOVA, *post-hoc* tests (*e.g.*, Tukey's Honestly Significant Difference (HSD)) were conducted to identify specific group differences. A significance level of $p < 0.05$ was adopted for all statistical tests, ensuring that the findings are statistically robust and reliable.

3. Results

3.1 General characteristics of the study population

The study included 2002 cases of prehospital primary hypertension managed by EMTs. Patients were categorized based on whether they were transported to the emergency department (ED) or left at the scene after stabilization.

- Transported patients were generally older, with a mean age of 65.2 years, compared to 63.4 years for those left at the scene.
- There was a slight predominance of males in the transported group (58%) compared to those left at the scene (52%).
- Initial SBP and DBP readings were higher in transported patients, with a median interquartile range (IQR) of 175.83 mmHg (160.5–190.2) for SBP and 94.84 mmHg (85.5–100.3) for DBP, compared to 151.50 mmHg (140.1–160.7) and 84.77 mmHg (77.8–90.2), respectively, for non-transported patients.

3.2 Response time analysis

The independent samples *t*-test revealed statistically significant differences in the time from receiving the call to completing the intervention, as well as the time from arrival to completing the intervention, depending on the decisions made by the EMT. Significantly more time was spent when the patient was transported to the ED, while significantly less time was spent when the patient was left at the scene or refused hospitalization. The decision of the EMT did not affect the time from receiving the call to arriving at the scene (Table 1).

3.3 Demographic characteristics by transport decision

A summary of the demographic characteristics of the patients, categorized by transport decision (Transported *vs.* Left at Scene), is presented in Table 2. The data reveal significant differences across various characteristics. Patients who were transported to the emergency department were generally older, with a median (IQR) age of 65.2 (60.0–70.5) years compared to 63.4 (58.0–68.7) years for those left at the scene, indicating that age may play a role in the decision to transport. Gender distribution also showed a slight predominance of males in the transported group (58%) compared to those left at the

TABLE 1. Response time and EMT decision.

| Time (min) | EMT Decision | N | Min | Max | Mean | Median | SD | <i>t</i> -Student Test |
|---------------------------------------|---------------|------|-----|-----|-------|--------|-------|--------------------------|
| From receiving to completing the call | | | | | | | | |
| | Left at scene | 1363 | 14 | 210 | 57.77 | 55 | 19.02 | $t = -22.563, p < 0.001$ |
| | Transported | 636 | 30 | 262 | 83.08 | 78 | 30.66 | |
| From receiving call to arrival | | | | | | | | |
| | Left at scene | 1363 | 0 | 184 | 12.02 | 11 | 8.92 | $t = 0.117, p = 0.907$ |
| | Transported | 636 | 0 | 91 | 11.97 | 10 | 8.26 | |
| From arrival to completing the call | | | | | | | | |
| | Left at scene | 1363 | 8 | 159 | 45.75 | 43 | 16.27 | $t = -25.662, p < 0.001$ |
| | Transported | 636 | 8 | 250 | 71.11 | 67 | 27.63 | |

EMT: Emergency Medical Teams; N: Sample Size; Min: Minimum; Max: Maximum; SD: Standard Deviation.

TABLE 2. Demographic characteristics by transport decision.

| Characteristic | Transported (n = 636) | Left at Scene (n = 1363) | p-value |
|--------------------------------------|--------------------------|-----------------------------|---------|
| Age (median (IQR)) | 65.2 (60.0–70.5) | 63.4 (58.0–68.7) | <0.001 |
| Gender (% male) | 58% | 52% | 0.045 |
| Initial SBP (median (IQR)) | 175.83 (160.5–190.2) | 151.50 (140.1–160.7) | <0.001 |
| Initial DBP (median (IQR)) | 94.84 (85.5–100.3) | 84.77 (77.8–90.2) | <0.001 |
| Medications Administered (mean ± SD) | 1.29 (1.0–1.8) | 1.75 (1.3–2.2) | <0.001 |

SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; IQR: Interquartile Range; SD: Standard Deviation.

scene (52%), suggesting potential gender differences in the severity of cases managed on-site. Significant differences were observed in the initial systolic and diastolic blood pressure readings. The transported group exhibited notably higher initial SBP and DBP values, with median readings of 175.83 mmHg (160.5–190.2) for SBP and 94.84 mmHg (85.5–100.3) for DBP, compared to 151.50 mmHg (140.1–160.7) and 84.77 mmHg (77.8–90.2), respectively, in the non-transported group. This indicates that higher blood pressure readings are a key factor influencing the decision to transport patients. Additionally, the number of medications administered was higher among patients left at the scene, with a median (IQR) of 1.75 (1.3–2.2) medications compared to 1.29 (1.0–1.8) in the transported group, suggesting that effective pharmacological management on-site may reduce the need for hospital transport.

3.4 Blood pressure analysis

The analysis of control blood pressure values further emphasizes the significant differences between the transported and non-transported groups (Table 3). Patients transported to the ED had higher median SBP and DBP values even after initial intervention, reflecting the critical nature of their condition and the need for further medical care. The difference in median SBP was particularly pronounced, with the transported group showing 175.83 mmHg (160.5–190.2) compared to 151.50 mmHg (140.1–160.7) in those left at the scene. Similarly, the median DBP for transported patients was 94.84 mmHg (85.5–100.3), significantly higher than 84.77 mmHg (77.8–90.2) observed in patients who were stabilized and left at the scene.

3.5 Medication combinations, dosage and EMT decision

The Chi-square test demonstrated a significant statistical relationship and a moderate correlation (V Cramer’s coefficient) between the combination of medications administered and the EMT’s decision. Patients who received combinations of medications such as captopril + hydroxyzine, furosemide + hydroxyzine, or captopril + furosemide + hydroxyzine were more frequently left at the scene compared to those transported to the ED. In cases without medication combinations or with captopril + furosemide, patients were slightly more often left at the scene than transported.

3.6 Medication combinations, frequency of administration and EMT decision

A detailed comparison of medication combinations and their frequency of administration is provided in Table 4. This analysis offers insight into how the specific combinations and dosages administered correlate with the decision to transport the patient or leave them at the scene. The p-value in Table 4 pertains to the comparison of medication combinations across the two groups: patients who were transported to the ED and those who were left at the scene. It highlights the statistical significance of the association between the specific combinations of medications administered (e.g., captopril + hydroxyzine, furosemide + hydroxyzine) and the EMT decision regarding whether to transport the patient or not. The data suggest that more complex combinations, involving three medications, were particularly effective in managing patients without the need for hospital transport, as indicated by the higher proportion of patients left at the scene in these cases. This finding emphasizes the value of tailored pharmacological

TABLE 3. Control BP values and EMT decision.

| Control BP | EMT Decision | N | Median (IQR) | p-value |
|------------|---------------|-----|----------------------|---------|
| SBP | Left at scene | 959 | 151.50 (140.1–160.7) | <0.001 |
| | Transported | 319 | 175.83 (160.5–190.2) | |
| DBP | Left at scene | 959 | 84.77 (77.8–90.2) | <0.001 |
| | Transported | 319 | 94.84 (85.5–100.3) | |

EMT: Emergency Medical Teams; BP: Blood Pressure; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; N: Sample Size; IQR: Interquartile Range.

TABLE 4. Medication combinations, frequency of administration and EMT decision.

| Medication Combination | Dosage | EMT Decision | Transported (n = 636) | Left at Scene (n = 1363) | Total | p-value |
|--------------------------------------|-----------------------|--------------|--------------------------|-----------------------------|-------|---------|
| None | - | Transported | 447 (70.3%) | 596 (43.7%) | 1043 | <0.001 |
| Captopril + Furosemide | 25 mg + 20 mg | Transported | 99 (15.6%) | 139 (10.2%) | 238 | |
| Captopril + Hydroxyzine | 25 mg + 25 mg | Transported | 42 (6.6%) | 306 (22.4%) | 348 | |
| Furosemide + Hydroxyzine | 20 mg + 25 mg | Transported | 21 (3.3%) | 165 (12.1%) | 186 | |
| Captopril + Furosemide + Hydroxyzine | 25 mg + 20 mg + 25 mg | Transported | 27 (4.2%) | 157 (11.5%) | 184 | |
| Total | - | - | 636 (31.8%) | 1363 (68.2%) | 1999 | |

EMT: Emergency Medical Teams.

strategies in prehospital hypertension management, particularly for reducing unnecessary hospital transports.

3.7 MAP Difference and EMT decision

The median (IQR) Mean Arterial Pressure (MAP) difference between the initial and control measurements showed significant variations based on EMT decisions. Patients who were left at the scene experienced a greater reduction in MAP, with a median (IQR) difference of 20 (13.33–27.67) mmHg, compared to 11.67 (5.33–17.67) mmHg in those transported to the ED. This greater reduction in MAP among non-transported patients suggests that EMTs were able to achieve effective blood pressure control on-site, reducing the necessity for hospital transport (Table 5).

4. Discussion

Our study highlights significant findings regarding the prehospital management of primary hypertension by EMTs during the COVID-19 pandemic. The analysis demonstrated that patients transported to the ED had significantly higher systolic and diastolic blood pressure compared to those left at the scene. This suggests that EMTs made transport decisions based on the severity of the patient's hypertension, with those who remained on-site responding better to initial pharmacological interventions. Moreover, patients who were stabilized and left at the scene exhibited a greater reduction in mean arterial pressure, indicating that effective pharmacological intervention can reduce the need for hospital transport in many cases.

In addition to optimizing EMT response times and medication administration, it is crucial to consider the training and education of EMT personnel. Continuous education programs that focus on the latest guidelines for managing hypertensive emergencies, especially in the context of pandemics, can significantly enhance the effectiveness of prehospital care. Research by Naylor *et al.* [18] supports the idea that regular

training and simulations can improve EMTs' clinical skills and decision-making abilities. Implementing these educational initiatives can ensure that EMTs are well-prepared to handle complex situations efficiently, thereby improving patient outcomes and resource utilization.

Our analysis of response times demonstrated that EMTs spent significantly more time on interventions when patients were transported to the emergency department compared to those left at the scene or who declined hospitalization. This prolonged intervention time can be attributed to the additional protocols and safety measures necessitated by the pandemic, such as the use of personal protective equipment (PPE) and thorough disinfection procedures.

These differences in response times can be attributed to several factors. When a patient is transported to the ED, EMTs are required to undertake additional steps that prolong the intervention time, including securing the patient for transport, continuous monitoring during the transport, and completing the necessary documentation for the handover to hospital staff. The enhanced COVID-19 protocols, such as PPE use and thorough disinfection procedures, likely contributed to the longer intervention times for transported patients.

Specifically, when transporting patients to medical facilities, EMTs were required to follow rigorous infection prevention procedures to minimize the risk of COVID-19 transmission. These procedures included not only wearing PPE but also thoroughly disinfecting the ambulance and medical equipment both before and after patient transport. Additionally, EMTs had to ensure that patients were properly isolated during transport, which sometimes involved using specialized barriers or equipment, further adding to the complexity and duration of the intervention.

There is evidence from other studies that these enhanced safety measures increased EMS response times, particularly in cases requiring transport to a hospital. For example, studies have shown that the time taken to don and doff PPE, combined

TABLE 5. MAP difference and EMT decision.

| EMT Decision | N | Min | Max | Median (IQR) | p-value |
|---------------|-----|--------|-------|---------------------|---------|
| Left at scene | 959 | -13.33 | 71.67 | 20.00 (13.33–27.67) | <0.001 |
| Transported | 319 | -26.67 | 93.33 | 11.67 (5.33–17.67) | |

EMT: Emergency Medical Teams; N: Sample Size; Min: Minimum; Max: Maximum; IQR: Interquartile Range.

with the need for comprehensive disinfection protocols, contributed to longer overall EMS intervention times during the pandemic. These findings align with our results, suggesting that while these procedures were essential for infection control, they also led to significant delays in EMS operations [19].

Streamlining these processes without compromising safety is crucial to improving response efficiency, especially in the context of ongoing or future public health emergencies. Future studies could focus on identifying ways to optimize these procedures to reduce their impact on response times while maintaining the necessary protective measures.

Moreover, our blood pressure analysis revealed that patients transported to the ED had significantly higher SBP and DBP readings compared to those left at the scene. This finding likely reflects the decision-making process of EMTs, where the choice to transport a patient is based on several factors, including the severity of hypertension and the patient's response to initial treatment attempts [20, 21]. Patients requiring transport often presented in more critical condition, necessitating more extensive care, such as the administration of multiple medications, detailed monitoring, and reassessment, all of which contribute to the longer time spent with these patients.

In many cases, EMTs attempt to control the patient's blood pressure with medication on the scene. If these attempts are unsuccessful or if the patient's condition is deemed too severe to be managed safely outside of a hospital setting, the EMTs may decide to transport the patient to the emergency department. This decision is often guided by established protocols and the clinical judgment of the EMTs, who assess the risk of complications based on the patient's current condition. Additionally, patient preference can play a role, particularly if the patient expresses a desire to be evaluated in a hospital despite some stabilization.

Given this context, it is reasonable to observe that patients who are transported typically have higher blood pressure readings, as these cases likely represent those where initial on-scene management was insufficient to achieve adequate control, or where the risk of severe outcomes was too high to leave the patient at the scene. This reinforces the importance of effective triage by EMTs, which is critical in ensuring that resources are appropriately allocated, and that patients at the greatest risk receive the necessary hospital care.

The significance of this triage process within the EMS system cannot be overstated. EMTs serve as the first line of medical intervention, and their ability to accurately assess and triage patients directly impacts patient outcomes and the overall efficiency of emergency medical services. Effective triage helps prevent unnecessary hospital transports, reducing the burden on emergency departments, while also ensuring that patients with more severe conditions receive timely and appropriate care. Future research could further explore the specific criteria used by EMTs in these decisions and how they might be optimized to improve outcomes.

The study examined the use of medication combinations by EMTs and their influence on transport decisions. Patients who received combinations of captopril, furosemide and hydroxyzine were more frequently left at the scene, indicating that EMTs often relied on these pharmacological interventions to stabilize hypertensive patients on-site. While hydroxyzine

is not typically a first-line treatment for hypertension, it was frequently used in combination with other medications in this study. Hydroxyzine, an antihistamine with sedative and anxiolytic effects, may have been administered to reduce anxiety in patients, which can indirectly contribute to elevated blood pressure. Its role in the treatment may reflect regional EMS practices or established protocols for prehospital hypertension management. The frequent use of hydroxyzine alongside captopril and furosemide suggests its value in managing the overall condition of hypertensive patients in emergency situations.

The use of specific medication combinations was typically guided by established protocols and, in some cases, direct medical direction provided by supervising physicians. These protocols likely influenced the choice of medication combinations, and further exploration of these protocols could provide insight into their efficacy. Further analysis of these protocols could help assess their efficacy in prehospital hypertension management.

Additionally, the number of medications administered was significantly higher for patients left at the scene compared to those transported. EMTs primarily used medications such as captopril, furosemide and hydroxyzine to manage hypertension in the field. These medications were selected based on their complementary effects in rapidly controlling blood pressure and stabilizing the patient. The use of specific medication combinations was typically guided by established protocols and, in some cases, direct medical direction provided by supervising physicians.

EMTs generally observed patients for a designated period after administering hypertensive medications to ensure the drugs took effect and to monitor the patient's response. This observation period allowed EMTs to assess whether the patient's condition was stable enough to remain at the scene or if hospital transport was necessary. The confidence in leaving patients at the scene after administering multiple medications suggests that EMTs relied on both the effectiveness of the medication and the patient's response during this observation period. This strategy not only alleviates the burden on EDs but also conserves EMS resources for more critical cases, aligning with studies that emphasize the importance of comprehensive prehospital care in improving patient outcomes and optimizing resource allocation.

Furthermore, our analysis of the mean arterial pressure differences revealed that patients left at the scene exhibited a higher MAP reduction compared to those transported to the ED. This significant reduction underscores the efficacy of prehospital interventions in managing hypertensive emergencies, enabling EMTs to stabilize patients adequately before making transport decisions. Other research has similarly highlighted the importance of achieving substantial MAP reductions in prehospital settings to prevent complications and ensure patient safety. The significant reduction in MAP among non-transported patients suggests that EMTs were able to achieve effective blood pressure control on-site, reducing the need for hospital transport. This emphasizes the efficacy of prehospital interventions in managing hypertensive emergencies.

Comparative studies have also highlighted regional differences in EMS protocols and the availability of resources, which

can impact the generalizability of findings. For example, a study by Newton *et al.* [22] in urban settings found that EMTs had access to more advanced medical equipment and support, leading to different intervention outcomes compared to rural settings. Our study's focus on the Bieszczady EMS operational area, which has its own unique challenges and resource limitations, adds valuable context to the broader understanding of prehospital hypertension management.

Comparative studies have shown that regional differences in EMS protocols can affect the generalizability of findings. In some areas, EMTs are legally restricted from administering medications before hospital admission, which limits the applicability of our results [23]. In such cases, EMTs must rely on non-pharmacological interventions, such as patient positioning and monitoring, and make transport decisions based on the severity of the patient's condition. While our study focuses on a region where EMTs can administer medications, the findings may not apply to areas with such restrictions. Further research is needed to explore effective EMS strategies in these contexts.

Our findings align with several studies, such as Kawa *et al.* [24] and Bashir *et al.* [25], which highlight the importance of effective prehospital care in reducing adverse cardiovascular events and managing resource constraints in rural areas. The prolonged intervention times observed during the pandemic are consistent with Varughese *et al.* [26] and Penney *et al.* [27], who reported increased EMS workload and complexity due to COVID-19 protocols. Furthermore, the efficacy of medication combinations found in our study is supported by Lindbeck [28] and Strandås *et al.* [21] emphasizing the role of tailored pharmacological strategies in prehospital care.

These findings have several practical implications for emergency medical practice. First, there is a need to enhance training for EMTs on efficient intervention techniques that adhere to safety protocols without causing significant delays. Studies have shown that targeted training programs can significantly improve the performance and decision-making skills of EMTs in managing hypertensive emergencies. Second, our results suggest that prehospital management protocols should include guidelines for the use of specific medication combinations to stabilize patients effectively on-site. This approach could reduce unnecessary hospital transports, freeing up ED resources for more critical cases. Previous studies have highlighted the benefits of tailored pharmacological strategies in prehospital care, suggesting that they can lead to better patient outcomes and more efficient use of medical resources. Third, the data underscores the importance of continuous monitoring and assessment of prehospital care practices. Implementing real-time feedback mechanisms and regular audits can help identify areas for improvement and ensure that EMTs are adhering to best practices. Research has demonstrated that continuous quality improvement initiatives in EMS can lead to significant enhancements in patient care and operational efficiency.

Overall our study provides valuable insights into the prehospital management of hypertension by EMTs during the COVID-19 pandemic. The findings highlight the importance of efficient intervention techniques, effective use of medications, and robust triage strategies. By addressing these areas, EMS systems can enhance the quality of care for hypertensive patients, optimize resource allocation, and improve overall

patient outcomes during public health emergencies. Further research and continuous evaluation are essential to refine these practices and ensure the readiness of EMS systems for future challenges.

5. Limitations

While our study provides valuable insights into the prehospital management of hypertension by Emergency Medical Teams during the COVID-19 pandemic, several limitations may affect the generalizability and interpretation of our findings.

First, the retrospective nature of the study limits our ability to control for potential confounding variables. Data were extracted from existing medical records, which may not have captured all relevant clinical details. This introduces potential biases related to documentation practices, and our findings are constrained by the quality and completeness of the available records. Incomplete or inconsistent documentation may have led to misclassification or missing data, affecting the reliability of the study outcomes.

Second, the accuracy of our data is dependent on EMT documentation practices, which may vary between individual EMTs and across shifts. Such variations could introduce inconsistencies, potentially affecting the overall validity of the study. Furthermore, the study was conducted within the operational area of the Bieszczady Emergency Medical Service, limiting the generalizability of our findings to other regions or EMS systems. Differences in EMS protocols, resources and patient demographics across regions may influence the applicability of our results in other settings.

Third, the unique conditions imposed by the COVID-19 pandemic significantly impacted EMS operations, patient behavior and hypertension management. Factors such as increased stress, reduced access to routine healthcare, and changes in patient behavior (*e.g.*, delaying care) likely influenced the prevalence and severity of hypertension. Additionally, infection control measures, including personal protective equipment use and disinfection protocols, affected EMT response times and decision-making. These pandemic-specific factors limit the comparability of our findings to non-pandemic contexts.

Although the study was conducted during the COVID-19 pandemic, our analysis does not differentiate between the pandemic and non-pandemic periods. Without this comparison, we cannot conclusively attribute our findings to COVID-19-specific effects, which may limit the broader applicability of the results. Future studies should aim to compare pandemic and non-pandemic periods to better understand these impacts.

Finally, our analysis did not account for several variables that could influence EMT decision-making and patient outcomes, such as the severity of comorbid conditions, patient preferences, or variations in EMT training and experience. Future research should aim to include these factors to provide a more comprehensive understanding of prehospital hypertension management in both pandemic and non-pandemic conditions.

6. Conclusions

Our study demonstrates that EMT interventions for prehospital hypertension are significantly longer when patients are transported to the ED compared to those left at the scene. Patients left at the scene had lower systolic and diastolic blood pressure readings and experienced a greater reduction in MAP, suggesting effective on-site management. Additionally, the higher number of medications administered to patients left at the scene highlights the role of pharmacological intervention in reducing hospital transport, potentially easing the burden on EDs.

These findings underscore the importance of efficient, targeted prehospital management strategies in hypertensive emergencies. By optimizing medication protocols and refining triage decisions, EMTs can improve patient outcomes and better allocate EMS resources.

Future research should focus on comparing data from COVID and non-COVID periods to understand the pandemic's impact on EMS operations. Additionally, further studies are needed to explore strategies for improving EMT training, medication administration, and long-term patient outcomes.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

AM and SK—conceptualization, methodology. KG and KZK—formal analysis. SK—investigation. MG and KG—supervision. KZK—validation. MG and AMAW—visualization. MG, AM, SK, KZK, AMAW and KG—writing—original draft. MG, AMAW and KG—writing—review. All authors have read and agreed to the published version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval for the current research was obtained from the Bioethics Committee at the Medical University of Lublin (decision number: KE-0254/150/06/2022). All participants provided informed consent to participate in this study, in accordance with the guidelines approved by the Bioethics Committee at the Medical University of Lublin.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Krzysztof Goniewicz and Ahmed M. Al-Wathinani are serving as the Guest editors of this journal. We declare that Krzysztof Goniewicz and Ahmed M. Al-Wathinani had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to TK.

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