Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Examining emergency medical services' prehospital transport times for trauma patients during COVID- 19

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ABSTRACT

Introduction: Longer prehospital times were associated with increased odds for survival in trauma patients. The purpose of this study was to determine how the COVID-19 pandemic affected emergency medical services (EMS) prehospital times for trauma patients.

Methods: This retrospective cohort study compared trauma patients transported via EMS to six US level I trauma centers admitted 1/1/19–12/31/19 (2019) and 3/16/20–6/30/20 (COVID-19). Outcomes included: total EMS prehospital time (dispatch to hospital arrival), injury to dispatch time, response time (dispatch to scene arrival), on-scene time (scene arrival to scene departure), and transportation time (scene departure to hospital arrival). Fisher's exact, chi-squared, or Kruskal-Wallis tests were used, alpha = 0.05. All times are presented as median (IQR) minutes.

Results: There were 9400 trauma patients transported by EMS: 79% in 2019 and 21% during the COVID-19 pandemic. Patients were similar in demographics and transportation mode. Emergency room deaths were also similar between 2019 and COVID-19 [0.6% vs. 0.9%, $p = 0.13$].There were no differences between 2019 and during COVID-19 for total EMS prehospital time [44 (33, 63) vs. 43 (33, 62), $p = 0.12$], time from injury to dispatch [16 (6, 55) vs. 16 (7, 77), $p = 0.41$], response time [7 (5, 12) for both groups, $p = 0.27$], or on-scene time [16 (12−22) vs. 17 (12,22), $p = 0.31$]. Compared to 2019, transportation time was significantly shorter during COVID-19 [18 (13, 28) vs. 17 (12, 26), $p = 0.01$].

Conclusion: The median transportation time for trauma patients was marginally significantly shorter during COVID-19; otherwise, EMS prehospital times were not significantly affected by the COVID-19 pandemic.

1. Introduction

Total EMS prehospital time is the time from dispatch to hospital arrival and is influenced by: response time (dispatch to scene arrival), on-scene time (scene arrival to scene departure), and transportation time (scene departure to hospital arrival) [1]. One study found that mortality is not affected by a shorter response time; however a longer on-scene time and a longer total prehospital times were associated with an increased odds of survival for trauma patients [1]. Alternatively, reaching definitive care within the "golden hour", the first hour after a traumatic injury, is thought to improve mortality rates [2].

Due to the coronavirus disease 2019 (COVID-19) pandemic, national social distancing guidelines were issued on March 16th, 2020, resulting in fewer people on the roads which could lead to shortened total EMS prehospital times [3]. The Bureau of Transportation Statistics data visualization tool displays approximately 130 billion trips in April of 2019 compared to 81 billion trips in April of 2020 [4]. However, COVID-19 relevant initiatives were implemented to EMS care guidelines, such as changes to personal protective equipment (PPE) use and screening patients for COVID-19, which could elongate the total EMS prehospital time [4,5]. The purpose of the study was to determine how the

Abbreviations: COVID-19, coronavirus disease 2019; EMS, emergency medical services; US, Unites States; PPE, personal protective equipment; IQR, interquartile range.

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COVID-19 pandemic affected EMS prehospital times for trauma patients.

2. Methods

This was a retrospective cohort study of adult trauma patients transported by EMS to six level I trauma centers from 1/1/19 to 6/30/20. Patients who were transferred from another facility ($n = 3682$) and patients whose time of dispatch was greater than 24 h from their time of injury ($n = 162$) were excluded from analysis. Patients admitted 1/1/20–3/16/20 ($n = 2062$) were excluded from analysis to control for potential confounding before national social distancing recommendations were issued. Comparisons were made based on admission date: patients transported 1/1/19–12/31/19 were the "2019" group and patients transported 3/16/20–6/30/20 were the "during-COVID-19" group. The median total EMS prehospital times were summarized for patients by their month and year of admittance and show a lack of pattern by seasonality suggesting weather was not affecting the total prehospital times. Because of this, all patients admitted in 2019 were included as the comparison group. Individual institutional review boards provided study approval for all six participating centers. Data were obtained from each trauma center's trauma registry.

The trauma centers participating in this study were located in Colorado, Kansas, Texas, and Missouri. During the COVID-19 study period, the trauma centers in Colorado resided in counties with between 333 and 463 confirmed cases of COVID-19 per 100,000 residents, the trauma center in Missouri was in a county with 157 cases per 100,000 residents, the trauma center in Texas was in a county with 290 cases per 100,000 residents and the trauma center in Kansas was in a county with 233 cases per 100,000 residents [6].

Among the participating centers, paramedics were screening for COVID-19 at the patient's home or in the ambulance. Screening consisted of questioning patients on symptoms and exposure history (when possible) as well as temperature checks. For patients who were suspected to have COVID-19, known to have COVID-19, or had an unknown COVID-19 status, EMS staff donned full PPE, including the use of close-fitting mask respirators with N95 cartridges or N100 masks and eye protection. Patients were also provided surgical masks to wear. Doffing of full PPE occurred after patient drop off. The receiving hospital would be notified of incoming patients who were suspected or known to have COVID-19. Expanded education on infectious disease process training for paramedics was implemented. After patient drop-off one center allowed for a decontamination period before picking up another patient and another center decontaminated with a disinfectant. Sheets were used to keep ambulance cabinets and general areas of the back of the ambulance clean for suspected and confirmed COVID-19 patients, to allow for easy turn over for the next patient at one center.

Patient demographics and clinical characteristics summarized included: age, gender, race, comorbidity (yes/no), mode of transportation (ambulance, helicopter, fixed-wing), pre-hospital cardiac arrest, initial field vitals (systolic blood pressure, heart rate, oxygen saturation, Glasgow Coma Scale), injury severity score (ISS), mechanism of injury, blood products administered in the first 24 h (red blood cells, fresh frozen plasma, platelets), initiation of massive transfusion protocol, emergency department disposition, and the number of patients admitted per day.

Study outcomes included: total EMS prehospital time (dispatch to hospital arrival), time from injury to dispatch, response time (dispatch to scene arrival), on-scene time (scene arrival to scene departure), transportation time (scene departure to hospital arrival), and time from injury to hospital arrival.

A prior study by Ageta et al. was used to calculate the sample size needed to see a difference in the total prehospital time [7]. Using a mean (SD) of 31.1 (11.6) minutes for patients in 2020, a mean (SD) of 33.0 (10.8) minutes for patients 2019, an alpha of 0.05 and a power of 80%, the total sample size needed was 2570 [7]. This equates to 1285 patients per group.

All continuous variables were non-parametric, are presented as median (interquartile, IQR) minutes, and were compared using the Kruskal-Wallis test. Dichotomous and categorical variables are summarized as proportions (count) and compared using chi-squared or Fisher's exact test, alpha = 0.05.

3. Results

There were 9400 patients: 79.2% (7446) in 2019 and 20.8% (1954) during COVID-19. There was a significantly larger median number of patients brought in via EMS per day in 2019 than during COVID-19, 20 patients per day vs 18 patients per day, $p = 0.0002$ (Table 1). Patients were similar in age, gender, and race. There was lower proportion of patients in 2019 admitted with any comorbidity than during COVID-19: 70.2% (5225) vs. 73.2% (1430), $p = 0.01$. There was a significantly lower proportion of patients with an injury severity score (ISS)

Table 1
Demographic and clinical characteristics

	2019 $n = 7446$	**COVID-19** $n = 1954$	*p*-value
Patients Per Day, Median (IQR)	20 (17, 23)	18 (14, 22)	0.0002
Patient Characteristics			
Age*, Median (IQR)	58 (35, 75)	57 (35, 74)	0.62
% Above 89 years old (n)	7.1% (533)	7.7% (151)	0.39
Gender, % Female (n)	44.9% (3346)	44.0% (859)	0.15
Race, % White (n)	75.5% (5624)	75.7% (1479)	0.88
Comorbidity, % Yes (n)	70.2% (5225)	73.2% (1430)	**0.01**
Transportation Mode % (n)			
Ambulance	93.8% (6983)	93.8% (1834)	0.90
Helicopter	7.2% (534)	7.3% (143)	0.82
Fixed Wing	1.1% (85)	1.0% (19)	0.52
Pre-hospital Cardiac Arrest % (n)	1.3% (84)	1.6% (26)	0.41
Initial Field Vitals Results			
SBP, % <90 mmHg (n)	3.1% (230)	3.5% (68)	0.36
HR, % > 110 bpm (n)	10.8% (800)	11.9% (230)	0.18
O2, % < 90% (n)	4.2% (306)	4.3% (83)	0.80
GCS, Median (IQR)	15 (15, 15)	15 (15, 15)	0.35
ISS, Median (IQR)	9.0 (4.0, 12.0)	9.0 (5.0, 13.0)	**0.01**
≤16	82.5% (6139)	80.3% (1569)	**0.03**
>16	17.6% (1307)	19.7% (385)	
Mechanism of Injury % (n)			
Fall	51.0% (3792)	51.2% (999)	**<0.0001**
MVC	21.8% (1620)	17.8% (348)	
MCC	4.6% (342)	7.8% (152)	
Other	22.7% (1687)	23.2% (452)	
Blood Products in the First 24 Hours % (n) Received			
pRBCs	4.0% (298)	3.8% (75)	0.74
FFP	3.2% (236)	2.4% (46)	0.06
Platelets	2.7% (198)	2.5% (48)	0.62
MTP	1.9% (143)	2.4% (46)	0.22
Emergency Department Disposition % (n)			
Floor	33.8% (2515)	30.3% (591)	**0.003**
Other**	24.5% (1823)	26.5% (517)	0.07
Intensive Care Unit	21.8% (1621)	22.7% (443)	0.39
Home	9.5% (706)	9.1% (178)	0.63
Operating Room	8.2% (609)	9.3% (182)	0.11
Transferred	0.6% (42)	0.4% (8)	0.40
Observation Unit	0.6% (44)	0.4% (8)	0.34
Died	0.6% (45)	0.9% (18)	0.13
Left AMA	0.3% (23)	0.2% (4)	0.44

SBP: systolic blood pressure; mmHg: millimeter of mercury; HR: heart rate; bpm: beats per minutes; RR: respiratory rate; O2: Oxygen saturation; GCS: Glasgow Coma Scale; ISS: injury severity score, COVID-19: novel coronavirus 2019; MVC: motor vehicle collision, MCC: motorcycle collision, pRBC: packed red blood cells; FFP: fresh frozen plasma; MTP: massive transfusion protocol; ED: emergency department, AMA: against medical advice.

* Age greater than 89 years was aggregated into a single category.

** Other ED Dispositions include psychiatric unit, telemetry unit, burn units, stepdown units, correctional facilities, acute care facility, and other internal locations.

of greater than 16 in 2019 compared to during COVID-19, 17.6% (1307) vs. 19.7% (385), $p = 0.03$.

The majority were brought in via ambulance: 93.8% (6983) in 2019 and 93.8% (1834) during COVID-19, $p = 0.90$. Helicopter and fixed-wing transport were not significantly different between groups, $p = 0.82$ and $p = 0.52$, respectively. Field vitals were comparable between groups. There was a higher proportion of motor vehicle collisions and a lower proportion of motorcycle collisions in 2019 when compared to during COVID-19, $p < 0.0001$.

There was no difference in the proportion of patients who received packed red blood celled ($p = 0.18$), platelets ($p = 0.16$), fresh frozen plasma ($p = 0.06$), or who had the massive transfusion protocol initiated ($p = 0.17$). The proportion of patients discharged from the emergency department to the floor was lower in 2019 compared to COVID-19, 33.8% (2515) vs. 30.3% (591), $p = 0.003$. Other emergency department discharge dispositions, including deaths occurring in the emergency department, were not statistically different between groups.

Fig. 1 shows the variability of the median total EMS prehospital time for patients by month and year of admittance. The median total EMS prehospital time ranged from as low as 38 min in December of 2019 to as high as 44 min in January of 2019 and trended slightly downward over time. After the implementation of social distancing guidelines in mid-March 2020, the median total EMS prehospital time decreased from 43 min to 40 min by May 2020 before starting to increase again in June 2020. A similar decrease in the total EMS prehospital time from March of 2020 to May of 2020 was observed in the same months of 2019.

Fig. 2 displays the EMS prehospital times for each study group. The median total EMS prehospital time was not statistically different between groups: 44 (33, 63) minutes in 2019 compared to 43 (33, 62) minutes during COVID-19, $p = 0.12$. The time from injury to dispatch was similar between groups: 16 (6, 55) minutes in 2019 and 16 (7, 77) minutes during COVID-19, $p = 0.41$. The response time was the same for both groups: 7 min (5, 12), $p = 0.27$. The on-scene time was similar in 2019 and during COVID-19: 16 (12, 22) minutes vs. 17 (12, 22) minutes, $p = 0.31$. The transportation time was significantly longer in 2019: 18 (13, 28) minutes, compared to during COVID-19, 17 (12, 26) minutes, $p = 0.01$. The time from injury to arrival was not significantly different, 67 (47, 140) minutes in 2019 compared to 73 (47, 182) minutes during COVID-19, $p = 0.10$.

EMS prehospital times are summarized by mode of transportation (ground ambulance, helicopter, and fixed-wing) in Table 2. Similar to the overall results, only the transportation time was significantly different for patients transported via ground ambulance, 17 (12, 26) minutes in 2019 compared to 16 (11,22) during COVID-19, $p = 0.03$. All other EMS prehospital times and the time from injury to arrival were statistically similar between groups for patients transported via helicopter and fixed-wing.

4. Discussion

During the COVID-19 pandemic, multiple factors could have affected total EMS prehospital time: fewer vehicles on the road, EMS process changes to prevent the spread of COVID-19, and prehospital screening for COVID-19 [8-10]. Existing publications examining the effect of COVID-19 on EMS focused on process changes to ensure staff safety and prevent the spread of COVID-19 [8,10]. Two studies reported on COVID-19 patients transported by EMS with one study examining the risk for COVID-19 among exposed EMS providers; these studies did not compare EMS prehospital times during COVID-19 to previous years' data [8,9]. This study is the first to our knowledge to determine how the pandemic affected EMS prehospital times for trauma patients. This study provides evidence that the total EMS prehospital time was not affected for trauma patients transported during COVID-19.

Among our trauma population, the total EMS prehospital time remained relatively short at 43 min, similar to the 2019 period at 44 min and to a meta-analysis reporting the national average for rural ground ambulance prehospital time of 42 min [11]. A systematic review reported that increased total EMS prehospital times and increased on-scene times were associated with improved mortality rates [1]. In this study, the majority (83%) of trauma centers reported screening for COVID-19 at the patient's residence, yet the on-scene time remained similar between groups. Elmer et al. reported a 3.8 min increase in the on-scene time during COVID-19; however their study included non-trauma patients who experienced an out-of-hospital cardiac arrest [12]. Additionally, the response time of seven minutes was unaffected by the COVID-19 pandemic. A previous study by Mell et al. reported that the median response time was also seven minutes [13]. A slightly shorter transportation time was observed during COVID-19, which was a median of one minute shorter, this may have been in part due to social distancing guidelines reducing the number of people on the road. Katayama et al. reported patients admitted for acute diseases in April of 2020 were 2.81 (2.14, 3.68) times as likely as patients in April of 2019 to experience a transportation time of more than 60 min, however there was no significant change in the odds of having a transportation time of more than 60 min for patients admitted for traffic accidents [14]. Alternatively, Scholz et al. reported no significant differences in dispatch time, on-scene time, transportation time, or total prehospital

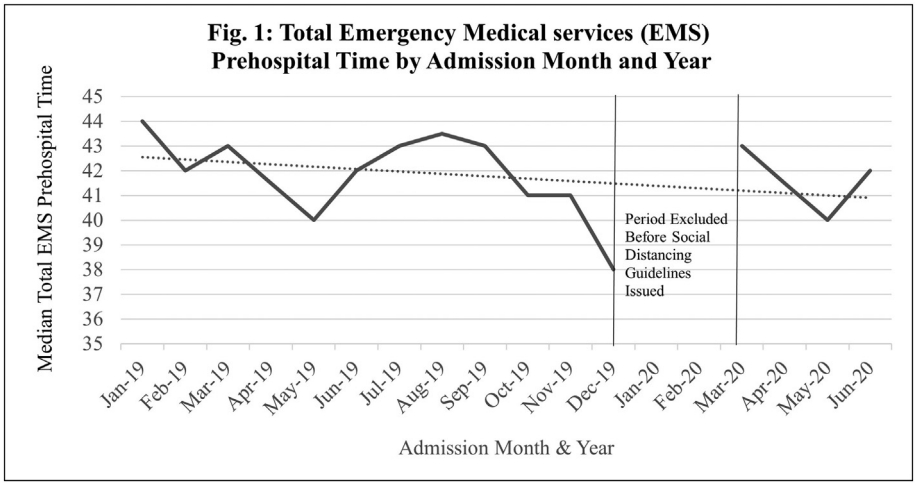

Fig. 1. Figure 1 displays the median total EMS prehospital time for all patients by month and year of admittance.

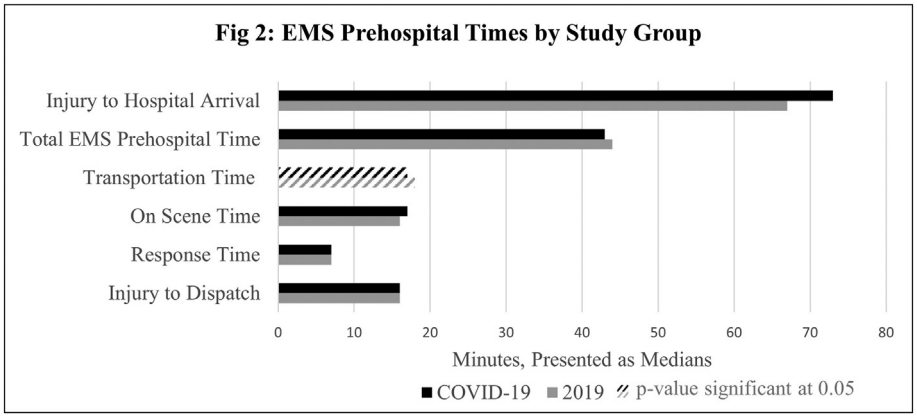

Fig. 2. Figure 2 displays the EMS prehospital times by study group. Significant differences are indicated with diagonal lines.

Table 2
EMS prehospital times by mode of transportation

	2019 n = 7446	COVID-19 n = 1954	p-value
Injury to Dispatch (Overall)	16 (6, 55)	16 (7, 77)	0.41
Ground Ambulance	15 (6, 46)	15 (6. 62)	0.27
Helicopter	26 (10, 88)	20 (10, 42)	0.32
Fixed-wing	256 (120, 420)	236 (125, 307)	0.45
Response Time (Overall)	7 (5, 12)	7 (5, 12)	0.27
Ground Ambulance	7 (5, 11)	7 (5, 10)	0.25
Helicopter	25 (17, 34)	23 (14, 31)	0.08
Fixed-wing	45 (10, 79)	61 (15, 99)	0.43
On Scene Time (Overall)	16 (12, 22)	17 (12, 22)	0.31
Ground Ambulance	16 (11, 22)	16 (11, 22)	0.17
Helicopter	20 (15, 30)	19 (14, 27)	0.28
Fixed-wing	37 (27, 56)	30 (24, 44)	0.09
Transportation Time (Overall)	18 (13, 28)	17 (12, 26)	**0.01**
Ground Ambulance	17 (12, 26)	16 (11, 22)	**0.03**
Helicopter	33 (24, 45)	31 (24, 45)	0.72
Fixed-wing	115 (72, 139)	119 (83, 129)	0.57
Total EMS Prehospital Time (Overall)	44 (33, 63)	43 (33, 62)	0.12
Ground Ambulance	42 (33, 60)	42 (32, 58)	0.13
Helicopter	85 (64, 106)	81 (65, 99)	0.10
Fixed-wing	198 (165, 243)	202 (170, 235)	0.97
Injury to Hospital Arrival (Overall)	67 (47, 140)	73 (47, 182)	0.10
Ground Ambulance	65 (46, 121)	68 (46, 155)	0.20
Helicopter	123 (90, 191)	104 (82, 196)	0.24
Fixed-wing	423 (303, 591)	442 (309, 510)	0.91

All times displayed in median (IQR) minutes. EMS: emergency medical services, COVID-19: coronavirus disease 2019.

time among patients with ST-segment elevation myocardial infarction [15]. Ageta et al. reported significantly longer total prehospital time, response time, and on-scene time during COVID-19 in a study examining all patients transported via EMS, excluding interfacility transport in an area minimally affected by COVID-19 [7]. It is possible that prehospital times are remaining similar for trauma patients but are changing among other populations, such as acute disease or other medical ailments.

Our findings for fixed-wing transportation time (119 min) were similar to those reported by Tien et al. for all transports (115 min) during the COVID-19 pandemic; however they reported 52.3% of patients were transported by ambulance and did not provide a breakdown of transportation time by mode of transportation [8]. When examining the prehospital times by mode of transportation, only patients transported by ground ambulance experienced a significantly shorter transportation time; all other modes of transportation and EMS prehospital times examined were similar.

Another key finding from our study was that there was a significantly lower median number of patients brought in via EMS each day during COVID-19, which could indicate that there were fewer traumatic injuries as seen at other trauma centers during the pandemic [16-18]. Similar to this study, Lerner et al. reported a significant 26.1% decrease in the weekly EMS call volume after social distancing guidelines were implemented due to the COVID-19 pandemic [19]. Satty et al. also reported a 26.5% decrease in EMS responses during COVID-19 [20]. Katayama et al. reported a decrease in the number of traffic accidents during COVID-19 [14].

Alternatively, fear of COVID-19 transmission may have led less critically injured patients to use private transportation rather than EMS [21]. We observed a significantly lower proportion of patients with an ISS of less than 16 brought in via EMS during the COVID-19 pandemic, it is possible these patients were utilizing private transportation instead of EMS. Huber et al. that patients brought in via EMS had a mean ISS of 20.1 whereas patients brought in via private transportation had a mean ISS of 14.4 [22]. Private transportation to the hospital could be troublesome as it may delay the initiation of treatment and knowledge of COVID-19 status upon hospital arrival. Huber et al. reported patients brought in by private transportation have a longer in-hospital time in the trauma room and a prolonged time to diagnostics [22]. Although there was a slightly higher proportion of patients admitted with an ISS of greater than 16 during COVID-19 than in 2019, there was no difference in the proportion of patients receiving blood products within the first 24 h or who had the massive transfusion protocol initiated. The field vitals were also the same between groups. This suggest the patients were well balanced in terms of their injuries and resuscitation needs.

4.1. Limitations

There were limitations to this study. This was a retrospective study with admission ending June 30th, 2020. While social distancing orders were in place throughout the COVID-19 study period, the timing of initiation and duration of lockdowns varied by location. There were differences observed in the mechanism of injury which could have been due to the enrollment dates. Factors other than COVID-19 not examined may have played a role in the study observations. While this study included trauma centers residing in counties with differing rates of COVID-19, the study may not be generalizable to all trauma centers.

5. Conclusions

The COVID-19 pandemic has burdened healthcare services in many ways. No meaningful differences were detected between EMS prehospital times during COVID-19 and in 2019 in this study. Maintaining prehospital EMS times similar to 2019 during COVID-19 was possible even with changes to EMS treatment protocols to conduct screening

for and prevent the spread of COVID-19 while providing optimal care for trauma patients. This is important as EMS prehospital times have shown to be a significant predictor of patient outcomes such as mortality. We recommend EMS follow guidance on providing care to patients during the COVID-19 pandemic to prevent the spread of COVID-19 and prehospital screening for COVID-19. Additionally, we recommend monitoring EMS prehospital times to ensure EMS prehospital times are not prolonged due to implementation of new procedures.

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Author contributions

Stephanie Jarvis, Kristin Salottolo, David Bar-Or, Gina M. Berg, Matthew Carrick, Rachel Caiafa, David Hamilton, and Kaysie Banton contributed to the conceptualization, investigation, methodology, drafting and reviewing of the manuscript. Stephanie Jarvis, Kristin Salotollo, and David Bar-Or, contributed to the project administration and supervision. Stephanie Jarvis and Kristin Salotollo contributed to the formal analysis.

Declaration of Competing Interest

None.

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