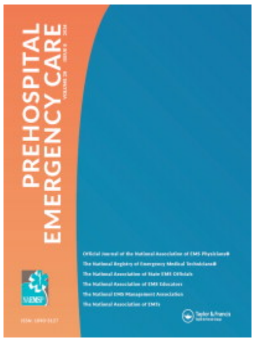

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ABSTRACT

Objectives: Emergency medical services (EMS) systems increasingly grapple with rising call volumes and workforce shortages, forcing systems to decide which responses may be delayed. Limited research has linked dispatch codes, on-scene findings, and emergency department (ED) outcomes. This study evaluated the association between dispatch categorizations and time-critical EMS responses defined by prehospital interventions and ED outcomes. Secondarily, we proposed a framework for identifying dispatch categorizations that are safe or unsafe to hold in queue.
Methods: This retrospective, multi-center analysis encompassed all 9-1-1 responses from 8 accredited EMS systems between 1/1/2021 and 06/30/2023, utilizing the Medical Priority Dispatch System (MPDS). Independent variables included MPDS Protocol numbers and Determinant levels. EMS treatments and ED diagnoses/dispositions were categorized as time-critical using a multi-round consensus survey. The primary outcome was the proportion of EMS responses categorized as time-critical. A non-parametric test for trend was used to assess the proportion of time-critical responses Determinant levels. Based on group consensus, Protocol/Determinant level combinations with at least 120 responses ($\sim$1 per week) were further categorized as safe to hold in queue ($<$1% time-critical intervention by EMS and $<$5% time-critical ED outcome) or unsafe to hold in queue ($>$10% time-critical intervention by EMS or $>$10% time-critical ED outcome).
Results: Of 1,715,612 EMS incidents, 6% (109,250) involved a time-critical EMS intervention. Among EMS transports with linked outcome data (543,883), 12% had time-critical ED outcomes. The proportion of time-critical EMS interventions increased with Determinant level (OMEGA: 1%, ECHO: 38%, p-trend $<$ 0.01) as did time-critical ED outcomes (OMEGA: 3%, ECHO: 31%, p-trend $<$ 0.01). Of 162 unique Protocols/Determinants with at least 120 uses, 30 met criteria for safe to hold in queue, accounting for 8% (142,067) of incidents. Meanwhile, 72 Protocols/Determinants met criteria for unsafe to hold, accounting for 52% (883,683) of incidents. Seven of 32 ALPHA level Protocols and 3/17 OMEGA level Protocols met the proposed criteria for unsafe to hold in queue.
Conclusions: In general, Determinant levels aligned with time-critical responses; however, a notable minority of lower acuity Determinant level Protocols met criteria for unsafe to hold. This suggests a more nuanced approach to dispatch prioritization, considering both Protocol and Determinant level factors.

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Introduction

Increasing emergency medical services (EMS) call volumes and workforce shortages create resource challenges, impeding the ability of agencies to respond immediately to every call for service (1–4). With multiple simultaneous requests for emergency response, often complicated by limited ambulance availability to meet call demand, dispatchers must decide which calls are emergent and thus require immediate response versus which may be safely deferred to preserve readiness until more resources are available (5,6). Many EMS systems utilize standardized dispatch response prioritization systems designed to match a response's acuity and urgency with appropriately resourced response units (5, 7–9). However, most dispatch systems were not designed to identify which calls need an immediate response versus which can be safely held in a queue.

In times of low unit availability, EMS systems may rely on the dispatch acuity Determinant level to determine which requests will receive immediate dispatch and which may be delayed for dispatch or referred to alternative options such as telemedicine or secondary nurse triage. However, this

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strategy may not incorporate other pertinent information within each dispatch prioritization chief complaint/Protocol that would predict the need for time-critical EMS intervention(s). There is low to very low overall level of evidence for the accuracy of medical dispatching systems (10). Prior research has focused on dispatcher adherence to algorithms and prearrival instructions, the need for Advanced Life Support (ALS) interventions, low-acuity calls, and non-transport (11–15). Other outcomes-driven research in prehospital medicine has focused on disease-specific conditions, such as sudden cardiac arrest, acute coronary syndromes, and stroke (16,17). Hettinger et al. reported that some dispatch Determinant level codes were associated with a predictive ability for ED discharge (18). However, a paucity of data robustly correlates standard dispatch systems to on-scene, time-sensitive EMS treatments and hospital patient outcomes.

There is an urgent need for evidence-based prioritization of EMS dispatches, especially when resources are limited (19). Our primary objective was to assess the association of emergency medical dispatch Protocol and Determinant levels from a widely adopted prioritization system with on-scene provision of time-critical intervention by EMS and emergency department outcomes. Secondarily, we sought to provide a proposed framework for how EMS systems could use this information in dispatch prioritization decisions, specifically as to whether a response likely requires immediate dispatch or could be safely held in queue.

Methods

Study Design & Setting

This retrospective multi-center analysis included eight EMS Systems whose dispatch centers are accredited by the International Academies of Emergency Dispatch (IAED) and who receive automated, structured outcomes from their receiving hospitals *via* a bi-directional Health Data Exchange platform leveraging HL7 messaging (ESO, Austin, TX). Participating systems are summarized in Table 1.

All EMS responses from January 1, 2021, to June 30, 2023, that resulted from a 9-1-1 dispatch with an associated assignment of an emergency medical dispatch code were eligible for inclusion. This analysis included 9-1-1 responses for interfacility transports as these represent a demand on the emergency system. Scheduled transfers were not included. The Institutional Review Board at Johns Hopkins University determined this study was exempt.

Table 1. Participating EMS agencies.

Agency name	Location
Austin Travis County EMS	Austin, TX
Charleston County EMS	Charleston, SC
Emergency Medical Services Authority	Tulsa and Oklahoma City, OK
Guilford County EMS	Guilford County, NC
Johnston County EMS	Johnston County, NC
Johnson County EMS System	Johnson County, KS
Lee County EMS	Lee County, FL
Wake County EMS	Wake County, NC

Independent Variable

Dispatch Protocols and Determinant Levels

Developed and maintained by the IAED, the Medical Priority Dispatch System (MPDS®) and the Fire Priority Dispatch System (FPDS®) represent a unified emergency dispatch system in more than 3,500 communications centers in 46 countries (20). During the study period, the EMS systems included in this study utilized MPDS v 13.1, 13.2, 13.3, 14.0, and FPDS v 7.1.

Priority Dispatch Codes consist of a numeric Protocol code representing the clinical condition (chief complaint) and an alphabetic Determinant level representing acuity to help guide the response. Determinant levels range from OMEGA for low acuity conditions, potentially qualifying for non-EMS response referrals, to ECHO for conditions requiring early recognition and immediate dispatch. Per the suggested mapping outlined in the National EMS Information Systems (NEMSIS) data dictionary, ECHO and DELTA responses are considered “critical,” CHARLIE and BRAVO are “emergent,” ALPHA is “lower acuity,” and OMEGA is considered “non-acute.” For analysis and a proposed framework, we grouped ALPHA and OMEGA together as lower acuity Determinant levels and BRAVO, CHARLIE, DELTA, and ECHO as higher acuity Determinant levels.

Outcome Measures

Time-Critical EMS Interventions and ED Outcomes

We conducted a multi-round electronic survey to generate a consensus list of EMS interventions, ED diagnoses, and ED dispositions classified as “time-critical.” A representative (either the medical director or a designee) from each participating agency was sent a link to an electronic survey (Qualtrics; Provo, UT). Each agency was allowed one vote in each survey round.

In the initial survey round, a list of EMS interventions from the list of available interventions in the EHR software (ESO; Austin, TX) was provided and ED diagnoses were presented as the Agency for Healthcare Research and Quality (AHRQ) Clinical Classifications for Software Refined (CCSR) groupings of ICD-10 diagnostic codes. Participants were asked to indicate which EMS interventions and ED diagnosis categories were time-critical, defined as: “intervention required in a matter of minutes to save life or maintain essential functions, or diagnosis codes associated with an illness or injury with a known time-critical intervention that impacts patient outcomes.” Any item identified by 75% or greater of respondents after the initial round of voting was included in the respective definition; items receiving less than 25% of the votes were determined not to meet the definition; items with between 25% and 74% of the votes were circulated through a second round of voting. After the second round of voting, any item that received at least 50% of the votes was included in the definition (Supplemental Tables 1 and 2). Additionally, an *a priori* decision was made to include any encounter with cardiac arrest after EMS arrival or any encounter with patient death in the ED in the definition of time-critical.

Time-critical EMS interventions were classified as basic life support (BLS) or advanced life support (ALS) based on the 2019 EMS National Scope of Practice Model (21).

Proposed framework for Safe or Unsafe to Hold in Queue

As a proposed framework for responses that may be considered "safe to hold in queue" for delayed dispatch during times of low unit availability, we selected a threshold of <1% time-critical intervention by EMS and <5% time-critical ED outcome based on consensus from the participating agencies' medical directors. To categorize responses as "unsafe to hold in queue" for delayed response during low unit availability, we selected a threshold of >10% time-critical intervention by EMS or >10% time-critical ED outcome.

Statistical Analysis

To evaluate the relationship of overall dispatch Determinant level (acuity level) with time-critical EMS intervention or ED outcome by Determinant level, we used the Cochran-Armitage non-parametric test for trend.

For analysis of Protocols/Determinants meeting the proposed safe to hold or unsafe to hold criteria, we limited the analysis codes with at least 120 (~1 per week) uses during the study period. We then described discordant Protocols within higher acuity Determinant levels (BRAVO, CHARLIE, DELTA, or ECHO) that met the safe to hold in queue for delayed dispatch threshold and Protocols within lower acuity Determinant levels (OMEGA, ALPHA) that met the unsafe to hold in queue for delayed dispatch threshold. Lastly, for Protocols/Determinants with >1% time-critical EMS intervention, we described the proportion of responses with time-critical prehospital interventions that could be performed entirely at the BLS level. The participating system medical directors selected a threshold of ≥75% of responses with BLS time-critical interventions as a potential framework for BLS response to fulfill the immediate need for time-critical EMS intervention. All analyses were completed using Stata version 18.0 MP (StataCorp LLC; College Station, TX). The alpha threshold was set at 0.05 for all comparisons to measure statistical significance.

Results

There were 1,963,242 encounters that generated one or more patient care reports during the study period, of which 1,715,612 had a valid MPDS code and were included in the analysis. Determinant level DELTA was the most common, comprising 27% ($n = 465{,}370$) of encounters, followed by CHARLIE at 25% ($n = 429{,}298$) and ALPHA at 25% ($n = 421{,}102$). Determinant level OMEGA was the least common at 2% ($n = 29{,}505$) of encounters (Table 2). Overall, 72% ($n = 1{,}232{,}611$) of encounters resulted in transport by EMS. The EMS transport rate varied by Determinant level from 49% among ECHO Determinant levels to 80% among CHARLIE determinants (Figure 1).

Approximately 6% ($n = 109{,}250$) of encounters included a time-critical intervention by EMS (Table 2). Among responses resulting in EMS transport with linked outcome data ($n = 543{,}883$), 12% ($n = 64{,}053$) had a time-critical ED diagnosis or disposition. As Determinant level acuity increased, the proportion of encounters with time-critical EMS intervention also increased (OMEGA: 1%, ECHO: 38%, p-trend < 0.01). Similarly, as Determinant level acuity increased, the proportion of encounters with time-critical ED outcomes increased (OMEGA: 3%, ECHO: 31%, p-trend < 0.01).

Example Prioritization Framework

There were 294 unique Protocol and Determinant level combinations, of which 162 were used at least 120 times during the study period, representing 1,712,538 total responses. Of the 162 Protocol/determinant combinations, there were 17 OMEGA, 32 ALPHA, 35 BRAVO, 32 CHARLIE, 38 DELTA, and 8 ECHO.

Of these 162 Protocol/Determinant combinations included in the example framework analysis, 30 Protocol/Determinant combinations met the proposed criteria for safe to hold in queue, accounting for 8% ($n = 142{,}067$) of total encounters. Discordant higher acuity Protocol/

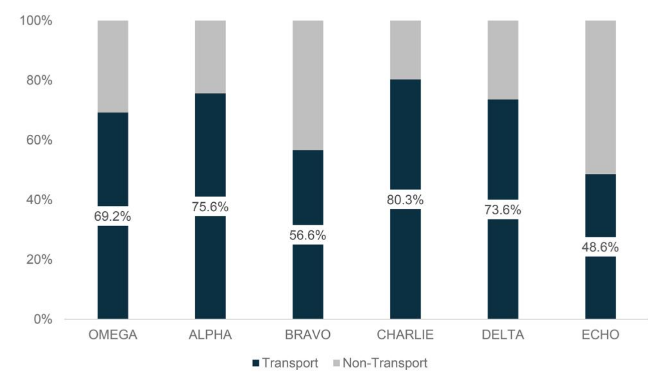

Figure 1. Proportion of encounters resulting in EMS transport by dispatch Determinant level ($N = 1{,}715{,}612$).

Table 2. Proportion of incidents with time-critical EMS intervention or time-critical ED outcomes by dispatch Determinant level.

Dispatch Determinant level	Col % (n)	Time-Critical EMS Intervention ($N = 1{,}715{,}612$)**	Time-Critical ED Outcome* ($N = 543{,}883$)**
OMEGA	1.7% (29,505)	1.0% (287)	2.8% (168)
ALPHA	24.6% (421,102)	1.4% (5,817)	5.8% (7,203)
BRAVO	19.4% (332,403)	3.7% (12,304)	11.7% (10,082)
CHARLIE	25.0% (429,298)	6.7% (28,901)	13.7% (21,808)
DELTA	27.1% (465,370)	10.2% (47,644)	14.0% (22,267)
ECHO	2.2% (37,934)	37.7% (14,297)	31.3% (2,525)
Total	1,715,612	6.4% (109,250)	11.8% (64,053)

*Denominator = EMS transport and ED diagnosis available. **Cochran-Armitage test of trend: $p < 0.001$.

Determinant combinations meeting proposed safe to hold criteria included 7 BRAVO, 2 CHARLIE, 1 DELTA, and 1 ECHO Determinant levels (Table 3).

Meanwhile, 72 Protocol/Determinant level combinations met criteria for unsafe to hold in queue, accounting for 52% ($n = 883{,}683$) of encounters. Of these meeting unsafe-to-hold criteria, discordant lower acuity Protocol/Determinant combinations included 7 ALPHA and 3 OMEGA Determinant levels (Table 4).

Overall, there were 120 Protocol/Determinant level combinations with >1% time-critical EMS intervention. Of these, 12 Protocol/Determinant level combinations had at least 75% of responses with time-critical EMS intervention needs met by BLS (Table 5).

Discussion

Our study represents the largest number of linked MPDS Protocols and Determinant levels associated with both EMS interventions and emergency department outcomes conducted to date. The inclusion of ED outcomes provides insight into patients who may not have received a time-critical EMS

Table 3. Discordant Protocols within higher acuity Determinant levels meeting proposed "safe to hold"* in queue criteria.

Protocol/Determinant level	Chief Complaint	Responses N = 142,067	% Transport Row % (n)	% Time-Critical EMS Intervention Row % (n)	% Time-Critical ED Outcome** Row % (n)
01B	Abdominal Pain	1,420	89.1% (1,265)	0.3% (4)	2.5% (36)
01 C	Abdominal Pain	19,912	91.0% (18, 114)	0.7% (147)	1.2% (232)
05 C	Back Pain (Non-Traumatic)	5,378	89.4% (4,806)	0.7% (38)	1.0% (53)
08B	Carbon Monoxide/ Inhalation/ Haz Mat/ CBRN	339	32.5% (110)	0.9% (3)	0.3% (1)
20B	Heat / Cold Exposure	1,935	61.7% (1,194)	0.9% (17)	0.5% (9)
24B	Pregnancy / Childbirth / Miscarriage	1,603	87.3% (1,399)	0.9% (15)	0.6% (9)
46B	Specialized (Scheduled) Interfacility Transfer	11,339	96.6% (10,954)	0.7% (78)	0.0% (0)
52B	Alarms	225	4.0% (9)	0.4% (1)	0.0% (0)
53B	Citizen Assist/Service Call	547	5.1% (28)	0.2% (1)	0.0% (0)
60D	Gas Leak/Gas Odor (Natural and LP Gases)	162	5.6% (9)	0.0% (0)	0.0% (0)
69E	Structure Fire	3,024	4.8% (146)	0.6% (18)	0.1% (4)

*Safe to hold in queue = <1% time-critical intervention by EMS and <5% time-critical ED outcome. **denominator = EMS transport and ED diagnosis available.

Table 4. Discordant Protocols within lower acuity Determinant levels meeting proposed "unsafe to hold"* in queue criteria.

Protocol/ Determinant level	Chief Complaint	Responses N = 883,683	% Transport Row % (n)	% Time-Critical EMS Intervention Row % (n)	% Time-Critical ED Outcome** Row % (n)
02O	Allergies (Reactions) / Envenomations (Stings, Bites)	649	76.6% (497)	1.4% (9)	17.6% (13)
02 A	Allergies (Reactions) / Envenomations (Stings, Bites)	3,347	54.8% (1,833)	7.6% (253)	36.6% (333)
09 O	Cardiac or Respiratory Arrest / Death	745	3.6% (27)	6.2% (46)	46.7% (7)
19 A	Heart Problems / AICD	1,391	56.9% (792)	0.4% (6)	20.8% (94)
21 O	Hemorrhage / Lacerations	362	55.8% (202)	2.5% (9)	12.1% (4)
31 A	Unconscious / Fainting (Near)	18,725	59.3% (11, 106)	1.5% (283)	10.2% (580)
33 A	Transfer / Interfacility / Palliative Care	8,034	93.5% (7,508)	4.7% (378)	16.6% (697)
37 A	Interfacility Evaluation/Transfer	1,442	91.3% (1,317)	11.1% (160)	40.8% (269)
46 A	Specialized (Scheduled) Interfacility Transfer	36,701	97.1% (35,626)	0.5% (174)	13.1% (20)
53 A	Citizen Assist/Service Call	1,897	62.1% (1,178)	2.3% (44)	10.6% (82)

*Unsafe to hold in queue = >10% time-critical intervention by EMS or >10% time-critical ED outcome. **denominator = EMS transport & HDE diagnosis available.

Table 5. Dispatch Protocols and Determinants with >1% responses involving time-critical EMS intervention and ≥75% of responses with time-critical EMS intervention needs met by BLS.

Protocol/Determinant Level	Responses	% Responses with Time-Critical EMS Intervention Row % (n)	% Responses with Time Critical Interventions met by BLS Row % (n)
3A	662	3.5% (23)	87.0% (20)
4 A	1620	1.1% (17)	76.5% (13)
21 O	362	2.5% (9)	100.0% (9)
21 A	6640	4.7% (315)	83.8% (264)
3B	1826	8.3% (151)	75.5% (114)
21B	18992	10.6% (2,003)	82.1% (1,644)
11 C	302	7.3% (22)	81.8% (18)
21 C	2774	11.5% (318)	80.2% (255)
23 C	20989	8.1% (1,696)	84.0% (1,424)
23D	8928	46.8% (4,180)	88.1% (3,682)
38D	1120	3.9% (44)	79.6% (35)
23E	2001	63.6% (1,273)	81.9% (1,042)

intervention but who nevertheless may benefit from rapid EMS response and transport.

Importantly, the overall proportion of EMS requests that resulted in a time-critical EMS intervention or ED diagnosis/disposition increased as Determinant level acuity increased. This progression from OMEGA to ECHO indicates the dispatch Protocol system functions reliably, both related to EMS interventions and the need for time-critical hospital admission. However, a small but important number of Protocols within lower acuity Determinant levels were associated with time-critical criteria and met this group's consensus definition for unsafe to hold in queue for delayed dispatch. The chief complaints (Protocol number) for low acuity Determinants associated with the proposed unsafe-to-hold categorization were of two varieties: 1). Chief complaints often associated with ventilation or circulation concerns such as allergic reactions and heart problems, and 2). Interfacility transfers. The former may indicate that these Protocols may not be ideal for delayed dispatch even with a lower acuity Determinant level, while the latter represents situations where delayed dispatch may be considered, depending upon the capabilities and clinical resources available in the referring facility. Although in some systems, interfacility transfers may be handled outside of the 9-1-1 system, we elected to include them in our study because the 9-1-1 center received the calls and thus needed to be evaluated in comparison with other requests for prioritization. Gathering sufficient information regarding the capabilities of the transferring facilities may allow for more accurate prioritization, as some of the time-critical interventions may not require EMS intervention. Even with these caveats, 8% of EMS requests met the example proposed definition of "safe to hold in queue," potentially representing an operationally meaningful proportion in a system that may be experiencing resource constraints.

Additionally, there were situations where an emergent acuity recommendation was associated with a relatively low probability of a time-critical situation, such as abdominal pain. This opens the possibility of adding these Protocol and Determinant level combinations to the list of requests that may be eligible to safely hold in queue rather than provide an immediate dispatch.

Interestingly, there was no clear monotonic association between the dispatch characteristics or the rate of time-critical encounters and the rate of transport. While the lack of transport associated with the ECHO determinant is consistent with the best practice of on-scene termination of unsuccessful resuscitations, the variability in transport rates for the other Determinant levels warrants further evaluation.

For EMS Systems with Basic Life Support (BLS) resources, a substantial proportion of time-critical EMS interventions were within the BLS scope of practice, either from a first response or a tiered transport perspective. Systems may consider dispatch of BLS first response and/or BLS transport resources in lieu of ALS resources, thus providing a meaningful option to maintain readiness while ensuring appropriate resources are available based on patient needs.

Limitations

This study evaluated a single dispatch prioritization system and thus may not be generalizable to other dispatch regimens. During the study period, each participating agency incorporated version updates asynchronously. Additionally, although the IAED accredited all the centers involved and thus participated in structured performance reviews, there still exists the possibility for local variability with the use of the dispatch Protocol system, such as nurse triage or direct referral to telemedicine. Several specialized Protocols exist related to various types of interfacility transfers (Acute Care Hospitals, Urgent Cares, Physician Offices, etc.), with each participating agency utilizing the portion of these most suited to their communities. Further, we did not evaluate lower frequency (less than ∼1 per week across 8 systems) Protocol and Determinant level combinations.

Emergency department outcomes were not available for all the hospital transports. This is because not all receiving facilities provide outcomes back to EMS, some participating facilities were not participating in the bi-directional data exchange for the entire study period, and some of the EMS records lacked sufficient information for the patient match to occur at the time of patient transfer. Nevertheless, similar data have been utilized for prior studies, and there are no meaningful differences in the patient populations for those with or without hospital outcomes (22).

Although we utilized an exhaustive method by which the study participants defined time-critical situations, others may arrive at different conclusions. This is particularly true with respect to the utilization of the AHRQ disease classifications. While this provided a validated framework for disease classifications, it is possible that many of the categories were overly broad and may have included patients whose acuity may have been lower than the study participants intended. Similarly, in the case of EMS interventions, not all instances of all treatments (e.g., bleeding control or cardioversion) may universally be required in a matter of minutes to save life or essential function. In all cases, however, we chose to err on the side of over-inclusion, as the evaluation of potential under-triage was the primary focus of the study. Definitions for thresholds selected for "safe to hold" in queue or "unsafe to hold" in queue also may vary from those identified through our consensus-based approach of participating system medical directors in this study. Lastly, as a retrospective analysis, this analysis is hypothesis generating, not hypothesis testing, and these results may not be generalizable to every EMS System.

Conclusions

When utilizing a widely incorporated EMS dispatch system, the acuity levels generally function as anticipated, aligning with increased time-critical EMS interventions and ED outcomes. Within a given Determinant level, time-critical intervention and outcomes varied across Protocols, with a small but important portion of Protocols within lower acuity Determinant levels meeting criteria for unsafe to hold in queue. Collectively, these findings highlight the need to consider both the chief complaint and the acuity at dispatch to minimize the possibility of under-triage regarding responses safe for delayed response or alternative dispositions. Further research is needed to evaluate for local variation and other factors that may be incorporated to optimize the predictive properties.

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Author contributions

MJL, RPC, and JBM conceived the project and designed the study. RPC queried the data, and BJM and ML oversaw data quality checks. BJM, RPC, and MJL collaborated on the study design, and RPC analyzed the data. All authors contributed substantially to establishing consensus definitions. MJL and BJL drafted the manuscript, and all authors contributed substantially to its revision. MJL takes responsibility for the paper as a whole.

Disclosure statement

MJL and AMM are consultants with Stryker Medical Education, Inc. MJL is a consultant with Cresilon, Inc. MJL is the uncompensated Stop the Bleed Coalition Chairperson. RPC, RE, and JBM are employees and equity holders with ESO.

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