Emergency Medical Dispatch Codes Association with Emergency Department Outcomes

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Abstract

Background. Emergency medical dispatch systems are used to help categorize and prioritize emergency medical services (EMS) resources for requests for assistance. **Objective.** We examined whether a subset of Medical Priority Dispatch System (MPDS) codes could predict patient outcomes (emergency department [ED] discharge versus hospital admission/ED death). **Methods.** This retrospective observational cohort study analyzed requests for EMS through a single public safety answering point (PSAP) serving a mixed urban, suburban, and rural community over one year. Probabilistic matching was used to link subjects. Descriptive statistics, 95% confidence intervals (CIs), and logistic regression were calculated for the 107 codes and code groupings (9E vs. 9E1, 9E2, etc.) that were used 50 or more times during the study period. **Results.** Ninety percent of PSAP records were matched to EMS records and 84% of EMS records were matched to ED data, resulting in 26,846 subjects with complete records. The average age of the cohort was 46.2 years (standard deviation [SD] 24.8); 54% were female. Of the transported patients, 70% were discharged from the ED, with nine dispatch codes demonstrating a 90% or greater predictive power. Three code groupings had more than 60% predictive power for admission/death. Subjects aged 65 years and older were found to be at increased risk for admission/death in 33 dispatch codes (odds ratio [OR] 2.0 [95% confidence interval 1.3–3.0] to 19.6 [5.3–72.6]). **Conclusions.** A small subset (8% of codes; 7% by call volume) of MPDS codes were associated with greater than 90% predictive ability for ED discharge. Older adults are at increased risk for admission/death in a separate subset of MPDS codes, suggesting that age criteria may be useful to identify higher-acuity patients within the MPDS code. These findings could assist in prehospital/hospital resource management; however, future studies are needed to validate these findings for other EMS systems and to investigate possible strategies for improvements of emergency response systems. **Key words:** emergency medical services; emergency medical service communication systems; retrospective studies; databases, factual; medical informatics; triage; MPDS codes; prediction

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Introduction

The goal of emergency medical services (EMS) is "to get the right care to the right patient at the right time."[1] In prehospital medicine systems, this process begins with a 9-1-1 call to a public safety answering point (PSAP). Most PSAPs use a standardized call-taking process whereby a series of scripted questions are able to quickly and precisely categorize the medical needs of the caller.[2] The Medical Priority Dispatch System (MPDS) provides such standardization for over 3,000 communities.[3] MPDS calls are assigned to one of up to 36 chief complaints, each represented by a number (chest pain [10], difficulty breathing [6], etc.). These are further divided into six determinants, Omega through Echo, each with its own set of descriptors. The final dispatch code, a combination of letters and numbers, is used in many systems to prioritize requests for assistance and dispatch the appropriate prehospital resources based on the acuity of the call.

The dispatch codes and the resources that they in turn mobilize are critical to providing safe and effective care to patients. Most studies looking at MPDS have focused on the accuracy of dispatch codes in regard to prehospital acuity[4–8] or are limited to specific complaints and diagnoses.[9–16] In addition, although a few codes incorporate age and gender into their algorithm, there are no studies to our knowledge that have examined age and gender with regard to a range

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of specific MPDS codes and their association with emergency department (ED) outcomes. There is reason to believe there is an association based on hospital studies,[17–19] but it is not clear if these same associations can be found in specific MPDS codes.

The goal of this investigation was to examine the relationship between MPDS codes assigned to 9-1-1 requests for EMS and subsequent ED outcomes (discharge and admission/death in the ED). We hypothesized that a subset of dispatch codes can predict patient outcomes with a positive predictive value of 90% or greater, and that age and gender can further refine the predictive value for dispatch codes.

METHODS

Study Design

This was a retrospective observational cohort study investigating all requests for EMS care captured through a single PSAP. This study was approved by the University of Rochester Research Subjects Review Board.

Population and Setting

The study took place in a Northeastern United States county consisting of mixed urban, suburban, and rural areas of 659 total square miles with a population of 735,343.[20] All 9-1-1 requests for service within the county are received by a single PSAP. All requests were handled by certified emergency medical dispatchers using MPDS Version 12.0, and the PSAP is accredited by the National Academies of Emergency Dispatch as a Center of Excellence.[21] The EMS system comprises 67 volunteer and paid transporting and first-response agencies employing a range of emergency medical technician (EMT)-Basic through EMT-Paramedic providers. The PSAP uses a tiered-response system, with customized responses based on geographic location and available resources. All agencies use a common set of medical care protocols. Agencies using an electronic medical record system accounted for 98% of the 104,940 emergency medical requests processed by the PSAP during the study period. The two study hospitals included a tertiary teaching hospital with approximately 97,000 ED visits annually and a smaller community hospital with approximately 37,000 ED visits annually. These two hospitals combined receive approximately 50% of the regional EMS transports annually.

Development of the Analytic Data Set

Subjects were included if EMS assistance was requested through the PSAP, the call was coded using the MPDS, and an EMS agency based within the county of study responded to care for the patient between January 15, 2009, and January 14, 2010. Records were excluded if the patient was transported to a nonstudy hospital or if the record was a duplicate due to multiple EMS units' being dispatched to the same request. All eligible cases from the PSAP, EMS agencies, and participating hospital EDs were obtained in electronic format.

Since not all the data elements were present in each data source, we used probabilistic matching theory to merge the data and match subjects from the three databases. This was most evident with the PSAP data set where no individual patient-identifiable information was recorded. Figure 1 contains the individual database elements and the linkages between them. Probabilistic record matching has been used previously to address the inherent difficulty found when linking multiple large data sets.[22–26] In this study we used the Fine-grained Records Integration and Linkage tool (FRIL, Version 2.1.4, Emory University, Atlanta, GA).[22] Prior to matching, the 319 unique dispatch codes used in the local system were condensed to 205 codes by clinical similarity through a process of two-physician review. For example, under the dispatch category "Animal Bites/Attacks," 3A1—Not Dangerous Body Area, 3A2—Non-Recent Injury (>6 hrs), and 3A3—Superficial Bites could be combined to make an assessment of the combined 3A dispatch category.

Outcome Measures

The primary outcome measurement was ED disposition, categorized as admission/death in the ED or discharge from the ED. For the purposes of analysis, admission to the hospital and death in the ED (a relatively rare event) was a combined outcome we defined as representing higher-acuity patients needing more ED resources.

Primary Data Analysis

Analysis was performed on the 107 most frequently used dispatch codes. We define the most frequently used codes as those that were used 50 or more times over the course of the year. The 50-call cutoff was decided a priori based on the power needed to determine at least a 10% difference from baseline patient disposition, assumed to be a 25% admission rate based on quality assurance data (29.7% in this study). In addition, our previous experience with MPDS demonstrated that this subset of codes would capture more than 90% of total call volume. Positive predictive values (PPVs) and 95% confidence intervals (CIs) were calculated[27] for each dispatch code based on ED outcomes, with admission/death defined as a true positive (TP) and discharge as a false positive (FP) ($PPV = TP/[TP + FP]$).

Stepwise logistic regression was used to investigate the effects of age (age 65 years and older) and gender

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PSAP	Prehospital	Hospital
Unique ID (PSAP_U)	Unique ID (P_UID)	Unique ID (H_UID)
PSAP Incident Number (D)(PSAP_ID)		
	ePCR Vendor (D)(ePCR_V)	
	ePCR Record Number (D)(ePCR_ID)	
		Medical Record Number (D)(H_MRN)
Initial Agency Dispatch (PSAP_Agency)	Agency Code (ePCR_Agency)	
Dispatch Code (PSAP_MPDSC)	Dispatch Code (ePCR_MPDSC)	
Call Location (PSAP_Loc)	Call Location (ePCR_Loc)	
Date of Call (PSAP_CDate)	Date of Run (ePCR_RDate)	Hospital Triage Date (D) (H_ADate)
Time of Call (PSAP_CTime)	Time of Call (ePCR_CTime)	
Time Enroute (PSAP_Enroute)	Time Enroute (ePCR_Enroute)	
Time Onscene (PSAP_Onscene)	Time Onscene (ePCR_Onscene)	
Time Leave Scene (PSAP_Leave)	Time Leave Scene (ePCR_Leave)	
Hospital Arrival Time(PSAP_ATime)	Hospital Arrival Time (ePCR_ATime)	Hospital Triage Time (H_ATime)
	Patient First Name (D)(ePCR_FName)	Patient First Name (D)(H_FName)
	Patient Middle Name (D)(ePCR_MName)	Patient Middle Name (D)(H_MName)
	Patient Last Name (D)(ePCR_LName)	Patient Last Name (D)(H_LName)
	Patient DOB (D)(ePCR_DOB)	Patient DOB (D)(H_DOB)
	Gender (ePCR_Gender)	Gender (H_Gender)
	EMS Disposition (ePCR_Disp)	Hospital Destination (H_Hosp)
		ED Disposition (H_ED_Dispo)
		Date of Admission (H_Admit)
		Date of Discharge (H_DC)

Figure 1. Database data elements and record linkage. EMS = emergency medical services; ePCR = electronic patient care report; PSAP = public safety answering point.

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(male). Age and gender were studied independently and in a combined model. MPDS codes that incorporated age and/or gender were noted and evidence for interaction between age and gender was also recorded. The Shapiro-Wilk test for normality was applied to the distribution of age for each MPDS code. Calculations were performed using SAS (Version 9.2, SAS Institute, Inc., Cary, NC).

Results

Characteristics of the Study Subjects

During the study period there were 104,940 requests for medical assistance (Fig. 2). Approximately 9% of the requests were not coded (typically requests for EMS made by law enforcement), leaving 95,379 MPDS coded calls. These coded requests for service were then linked to 101,429 EMS records. Excluding duplicate records and multiple dispatched units to the same call resulted in 86,263 (90.4%) MPDS-coded PSAP records matched to EMS records. Just over a third (32,302) of the matched PSAP subjects were transported to the study hospitals, with the remainder going to other hospitals or not being transported. Of these, 27,017 (83.6%) were matched to participating hospital ED records. A small number of patients (171) listed as "other" either left without being seen or a specific disposition was not recorded. The final analysis was performed on this group of 26,846 subject records. One hundred seven dispatch codes had more than 50 calls for the study period, which accounted for 92% of total call volume (Supplemental Material 1; available online only).

The study population consisted of 54.4% female patients (95% CI 53.8, 54.9); the mean age was 46.2 years (±24.8 standard deviation [SD]), with 23.6% over the age of 65 years; and 70.3% (69.7%, 70.8%) of patients were discharged from the ED (Table 1). The 10 most commonly used codes (Table 2) had between 560 and 2,068 patients. The highest PPVs for discharge from the ED (Table 3) ranged from 89.8% (82.9, 94.6) for 1C4 (Abdominal Pain–Females with Fainting or Near Fainting, Age 12–50) to 96.7% (88.5, 99.6) for 4A(1–2) (Assault/Sexual Assault–Not Dangerous Body Area/Non-Recent Injury). The highest PPVs for combined admission/death from the ED (Table 4) ranged from 54.3% (48.8, 59.6) for 26D1 (Sick Person–Not Alert) to 72.2% (64.2, 79.4) for 28C3 (Stroke–Speech).

The effects of age and gender were investigated separately and in a combined model. There were no significant changes to the effects of each variable when

Table 1. Patient Characteristics

	Study Patients	All Patients
N	26,846	86,263
Female (% (95% C.I.)	54.4% (53.8, 54.9)	56.1% (55.8, 56.5)
Age (years) mean (SD)	46.2 (24.8)	49.8 (25.5)
Discharged (% (95% C.I.)	70.3% (69.7, 70.8)	Unknown

CI = confidence interval; SD = standard deviation.

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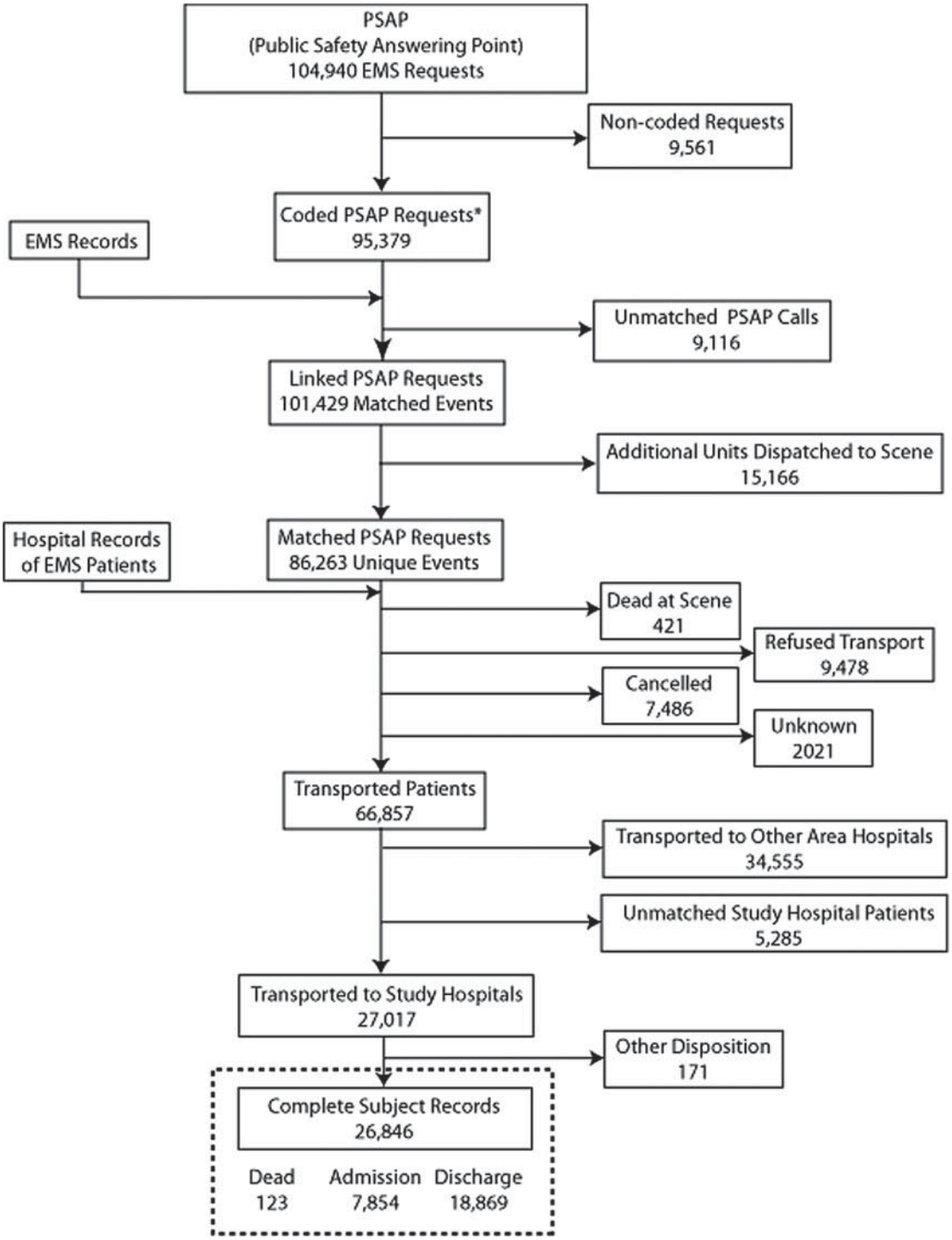

FIGURE 2. Patient flow. EMS = emergency medical services; PSAP = public safety answering point. *One PSAP request may represent multiple patients.

comparing the individual variable with the combined model; therefore, only combined-model results are presented. There were no significant associations of gender with ED outcome. After accounting for possible interaction ($p < 0.05$) and checking for normality ($p < 0.05$), we found 33 MPDS codes to have significant odds ratios for the association of age 65 years or more with hospital admission/ED death (Table 5). The results ranged from 2.0 (1.3–3.0) to 19.6 (5.3–72.6). For example, a 75-year-old subject with code 5A2 (Back Pain–Non-Recent Traumatic Back Pain) is at least 4.3 times more likely to be admitted/die than an 18-year-old. The PPVs and odds ratios for the combined model of age and gender for all studied codes are

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TABLE 2. Ten Most Commonly Used Dispatch Codes

MPDS Code	n	Discharge (95% CI)	Admission/Death (95% CI)
26A1—Sick Person–No Priority Symptoms	2,068	70.2 (68.1–72.1)	29.8 (27.9–31.9)
6D2—Breathing Problems–Difficulty Speaking Between Breaths	1,423	60.0 (57.4–62.6)	40.0 (37.4–42.6)
29B1—Traffic Accidents–Injuries	943	93.6 (91.9–95.1)	6.4 (4.9–8.1)
17B1—Falls–Possibly Dangerous Body Area	890	73.4 (70.3–76.2)	26.6 (23.8–29.7)
25A1—Psych/Abnormal Behavior/Suicide Attempt–Non-Suicidal and Alert	878	67.1 (63.9–70.2)	32.9 (29.8–36.1)
25B3—Psych/Abnormal Behavior/Suicide Attempt–Threatening Suicide	781	71.8 (68.5–75.0)	28.2 (25.0–31.5)
1A1—Abdominal Pain	689	78.8 (75.6–81.8)	21.2 (18.2–24.4)
6C1—Breathing Problems–Abnormal Breathing	683	62.2 (58.5–65.9)	37.8 (34.1–41.5)
17A1—Falls–Not Dangerous Body Area	671	58.0 (54.1–61.7)	42.0 (38.3–45.9)
12D2—Convulsions/Seizures–Continuous/Multiple Seizures	560	77.9 (74.2–81.2)	22.1 (18.8–25.8)

CI = confidence interval; MPDS = Medical Priority Dispatch System.

TABLE 3. Ten Dispatch Codes with the Highest Discharge Positive Predictive Value

MPDS Code	n	Discharge (95% CI)	Admission/Death (95% CI)
4A—Assault/Sexual Assault–Not Dangerous Body Area/Non-Recent Injury	60	96.7 (88.5–99.6)	3.3 (0.4–11.5)
31A3—Unconscious/Fainting–Fainting Episode, Alert, Age < 35 (With Cardiac History)	102	95.1 (88.9–98.4)	4.9 (1.6–11.1)
4B1—Assault/Sexual Assault–Possible Dangerous Body Area	223	94.6 (90.8–97.2)	5.4 (2.8–9.2)
29B1—Traffic Accidents–Injuries	943	93.6 (91.9–95.1)	6.4 (4.9–8.1)
10A1—Chest Pain–Breathing Normally, Age <35	132	93.2 (87.5–96.8)	6.8 (3.2–12.5)
26O2—Sick Person–Non-Priority Complaints	50	92.0 (80.8–97.8)	8.0 (2.2–19.2)
2C1—Allergic Reaction/Envenomations(Sting/Bite)–Difficulty Breathing or Swallowing	105	91.4 (84.4–96.0)	8.6 (4.0–15.6)
2A—Allergic Reaction/Envenomations(Sting/Bite)–No Diff Breathing/Swallowing	80	91.3 (82.8–96.4)	8.8 (3.6–17.2)
4B3—Assault/Sexual Assault–Unknown Status/Other Codes Not Applicable	67	91.0 (81.5–96.6)	9.0 (3.4–18.5)
1C4—Abdominal Pain–Females With Fainting or Near Fainting, Age 12–50	118	89.8 (82.9–94.6)	10.2 (5.4–17.1)

CI = confidence interval; MPDS = Medical Priority Dispatch System.

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available in Supplemental Material 2 (available online only).

DISCUSSION

In this EMS system a subset of dispatch codes had a significant association with ED outcomes above and beyond the baseline ED discharge rate of 70.3%. Specifically, nine commonly used emergency medical dispatch codes had a 90% or greater PPV for ED discharge (Table 3), including 4A(1–2)/4B1/4B3 (Assault/Sexual Assault), 31A3 (Unconscious/Fainting), 29B1 (Traffic Accidents), 10A1 (Chest Pain), 26O2 (Sick Person), and 2A/2C1(Allergic Reaction). Three dispatch code groupings had a greater than 60% PPV for admission/death for transported patients, including 28C1/28C3 (Stroke) and 9E (Cardiac/Respiratory Arrest). This represents a significantly higher admission/death rate than that of 29.7% observed in all patients transported to the hospital. Lastly, the effects of age on the predictive power of dispatch codes were highly variable. The effects were seen most notably for 5A2 (Back Pain), 26B1 (Sick Person), 17A2 (Falls), and 10D3 (Chest Pain), whereby age 65 years and older was associated with increasing probability of admission/death. There were no significant correlations with gender in those codes that did not already incorporate gender.

This study is one of the largest looking at the relationship between emergency medical dispatch codes and subsequent ED outcomes. Previous research has shown certain subsets of codes to be indicative of patients with low acuity[4] or more likely to require basic life support (BLS),[5,6] although a follow-up study

TABLE 4. Ten Dispatch Codes with the Highest Admission/Death Positive Predictive Value

MPDS Code	n	Discharge (95% CI)	Admission/Death (95% CI)
28C3—Stroke–Speech	144	27.8 (20.6–35.8)	72.2 (64.2–79.4)
9E—Cardiac/Respiratory Arrest/Death–Not Breathing At All/Agonal	129	32.6 (24.6–41.4)	67.4 (58.6–75.4)
28C1—Stroke–Not Alert	146	35.6 (27.9–44.0)	64.4 (56–72.1)
33C5—Interfacility/Palliative Care–Acute Severe Pain	60	40.0 (27.6–53.5)	60.0 (46.5–72.4)
17A3—Falls–Public Assist, No Injuries, No Priority Symptoms	96	40.6 (30.7–51.1)	59.4 (48.9–69.3)
33C2—Interfacility/Palliative Care–Abnormal Breathing/Acute Change	163	42.9 (35.2–50.9)	57.1 (49.1–64.8)
33C1—Interfacility/Palliative Care–Not Alert–Acute Change	79	44.3 (33.1–55.9)	55.7 (44.1–66.9)
26C1—Sick Person–Altered Level of Consciousness	216	44.4 (37.7–51.3)	55.6 (48.7–62.3)
25D1—Psych/Abnormal Behavior/Suicide Attempt–Not Alert	55	45.5 (32.0–59.4)	54.6 (40.6–68.0)
26D1—Sick Person–Not Alert	341	45.8 (40.4–51.2)	54.3 (48.8–59.6)

CI = confidence interval; MPDS = Medical Priority Dispatch System.

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TABLE 5. Association of Subject Age 65 Years or Older with Hospital Admission/Emergency Department Death

MPDS Code	OR–Age (95% CI)
2C1—Allergic Reaction/Envenomations(Sting/Bite)–Difficulty Breathing or Swallowing	4.8 (1.2–19.4)
5A2—Back Pain–Non-Recent Traumatic Back Pain	19.6 (5.3–72.6)
9E—Cardiac/Respiratory Arrest/Death–Not Breathing At All/Agonal	2.6 (1.5–4.5)
10C1—Chest Pain–Abnormal Breathing	3.3 (2.0–5.5)
10D3—Chest Pain–Changing Color	7.6 (2.8–20.5)
12A1—Convulsions/Seizures–No Seizing and Breathing Effectively	2.8 (1.5–5.4)
12C1—Convulsions/Seizures–Focal Seizure–Not Alert	4.7 (1.4–16.0)
17A1—Falls–Not Dangerous Body Area	4.4 (3.2–6.0)
17A2—Falls–Not Recent Injuries, No Priority Symptoms	7.1 (2.7–19.0)
17B1—Falls–Possibly Dangerous Body Area	3.8 (2.8–5.0)
17B3—Falls–Unknown Status/Other Codes Not Applicable	4.3 (2.1–8.9)
21B1—Hemorrhage/Laceration–Possible Dangerous Hemorrhage	2.4 (1.4–4.0)
21B2—Hemorrhage/Laceration–Serious Hemorrhage	2.5 (1.2–5.2)
21D2—Hemorrhage/Laceration–Not Alert	2.7 (1.1–6.5)
21D3—Hemorrhage/Laceration–Dangerous Hemorrhage	4.1 (2.4–7.0)
21D4—Hemorrhage/Laceration–Abnormal Breathing	3.7 (1.4–10.2)
23B1—Overdose/Ingestion/Poisoning–Overdose Without Priority Symptoms	3.7 (1.9–7.3)
26B1—Sick Person–Unknown Status/Other Codes Not Applicable	10.8 (4.6–25.1)
28C1—Stroke–Not Alert	2.5 (1.3–5.1)
28C3—Stroke–Speech	2.7 (1.3–5.6)
28C4—Stroke–Numbness, Paralysis, Movement Problems	2.8 (1.3–6.1)
29D2P—Traffic Accident–High Mechanism-Rollover	2.9 (1.1–7.6)
30A1—Traumatic Injuries–Not Dangerous Body Area	2.2 (1.3–3.8)
31C1—Unconscious/Fainting–Alert With Abnormal Breathing	3.2 (1.5–6.8)
31D1—Unconscious/Fainting–Unconscious–Agonal/Ineffective Breathing	3.9 (1.8–8.1)
31D2—Unconscious/Fainting–Unconscious–Effective Breathing	3.2 (1.9–5.3)
31D3—Unconscious/Fainting–Not Alert	3.4 (2.3–4.9)
32D1—Unknown Problem(Man Down)–Life Status Questionable	2.9 (1.4–6.3)
33C1—Interfacility/Palliative Care–Not Alert–Acute Change	2.3 (1.2–4.5)
33C2—Interfacility/Palliative Care–Abnormal Breathing/Acute Change	2.0 (1.3–3.0)
36O1—Pandemic Flu–Flu Symptoms Only	4.2 (1.5–11.3)

CI = confidence interval; MPDS = Medical Priority Dispatch System; OR = odds ratio.

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in a different population failed to demonstrate the same distribution of low-acuity patients.[7] Others have shown certain codes to have increased sensitivity for the detection of out-of-hospital cardiac arrest[9,28,29] or high acuity in the prehospital setting,[29] but did not examine ED outcome. Some dispatch systems have shown a correlation between dispatched versus utilized prehospital resources[8,30,31] as well as physician determination of medical need at ED presentation,[32] but were limited in the lack of outcome data. Several studies have shown, with varying levels of success, the predictive abilities of prehospital information in determining the likelihood of admission. They used either patient characteristics[33,34] or provider assessment,[35–37] but did not focus on information available at the time of dispatch. Although there has been study into the predictive value of MPDS for hospital- based patient outcomes/diagnosis, previous studies focused on specific disease process/conditions, such as cardiac disease,[10] stroke,[11–13] and "obvious death."[14] To our knowledge, this is the largest study to date linking MPDS code to ED outcome.

The ability to link prehospital data sets to ED or hospital outcome is critical in furthering research in prehospital medicine. The methods utilized in this study were able to obtain a highly successful match rate (83.6% and 90.4%) when compared with previous studies in the prehospital setting that also used probabilistic matching (5.9%–77.7%).[25,26,38] Beyond different software and hardware, the improved results are likely a result of differences in matching algorithms, including the use of manual matching, variables used for matching, and differences in data sources. These combined elements, a large data set, and a high match rate allowed for investigation into nearly all dispatch codes instead of focusing on a specific complaint/diagnosis, e.g., cardiac emergencies or stroke.[10,13,16]

This study has several important implications for EMS operations, health policy, and research. Based on our analysis, there appear to be significant differences between codes, and specific codes may need to be further refined. For instance, it would be easy to assume that a large number of medical alert alarms are nonacute or mistaken calls. However, for patients transported to the hospital for the dispatch code 32B2—Unknown Problem(Man Down)–Medical Alarm(Alert) (No Patient Info), 49% were admitted or died in the ED. Previous research has also identified subsets of patients in the "unknown problem" protocol (32) as having a high acuity and risk for cardiac arrest.[39] Further investigation may show that these patients will benefit from a higher-priority assignment, such as advanced life support (ALS) evaluation, dispatch of additional units, or priority over

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other calls. However, research will also need to assess whether a particularly large number of patients are admitted for nonmedical reasons (i.e., admission for placement into long-term care).

Our results suggest that the predictive values of certain codes for hospital admission/discharge increase when accounting for patient age (Table 5; Supplemental Material 2, available online only). For example, four of the "Fall" dispatch codes (17A1/17A2/17B1/17B3) show age as independently associated with hospital admission/death, including 17A1—Falls–Not Dangerous Body Area and 17A2—Falls–Not Recent Injuries, no Priority Symptoms, which would seem to select out the patients with less-acute conditions. MPDS currently uses age in determining a response in the Abdominal Pain (1), Back Pain (5), Chest Pain (10), Convulsions/Seizures (12), Heart Problems (19), Stroke (28), Unconscious/Fainting (31), and Pandemic Flu (36) categories. It is possible that age should be included in more codes, including Allergic Reaction/Envenomations (2), Cardiac/Respiratory Arrest (9), Falls (17), Hemorrhage/Laceration (21), Overdose (23), Sick Person (26), Traffic Accidents (29), Traumatic Injuries (30), and Interfacility/Palliative Care (33), where each code had at least one determinant with a significant association for hospital admission/death and age.

The described methodologies could be adopted by other communities that use MPDS to determine their acceptable risk–benefit of dispatching limited resources. Similar study designs are already under way for patients evaluated for stroke.[40] Knowing the ED outcomes of patients by MPDS code may allow medical directors to adjust the resources sent (ALS, BLS, or first response) and the mode of response (lights and sirens versus nonemergency), as well as identify MPDS codes that may be appropriate for a delayed response in circumstances of unusually high volume. Determining the community's acceptable risk–benefit with such outcome data may also facilitate the consideration of alternative destinations or referral to telemedicine resources at the time the call is received and processed.

Taking the concept of resource allocation even further, the predictive values of admission/death could be used for the automatic advanced notification of hospitals in order to optimize resource utilization. Most EMS units notify hospitals once they are en route to the receiving facility, which may only be a matter of minutes before arrival at an ED. A system utilizing predictive technologies could give a significantly longer period of notification, especially if a large number of units are dispatched in a short period of time. This feature could also be matched with the selective routing of transporting units during times of high volume. For example, patients who have a high likelihood of being discharged from the ED based on their MPDS code could be directed to institutions that have available ED beds but a limited number of inpatient beds. Those patients with a higher level of acuity could be directed toward hospitals with a larger number of inpatient or intensive care unit beds available. A selective routing system and change in dispatching methods could impact the time that EMS units spend waiting in ED triage when hospitals are overcrowded.[41,42] This is particularly important when EMS demand outstrips supply of responding units, which can in turn lead to longer emergency response times.[43,44] Further research is needed to evaluate the possible economic impact of early notification and selective routing of patients based on dispatch coding, particularly if fewer units are able to cover the same number of calls. Integration into system status management applications and/or regional health information networks could automate the process and provide continuous information on not only current resource utilization, but predicted outcomes, including potential early warning for patient surges.

Limitations and Future Research

An important limitation is our use of retrospective data from large clinical data sets not originally designed with research questions in mind. This is a potential source for bias because the sickest patients are less likely to have complete demographic information recorded, resulting in decreased match rates among the sickest patients and underestimating the hospitalization and/or mortality rate of all dispatch codes. Furthermore, the combined endpoint of admission and death as a marker for higher-acuity patients was necessary because of the limitations of this retrospective analysis. Future study designs could use prospective techniques and better differentiate between patients who required significant medical treatment in the prehospital and hospital setting, those who were pronounced dead soon after arrival, those requiring hours of acute care, and others placed in short-stay observation beds. In addition, our overall goal of identifying dispatch codes that require greater resources in a hospital is better served with a combined endpoint than by excluding the small but important group of patients who die and have a potential to require a significant amount of care prior to their death.

A second limitation is the use of probabilistic matching with limited manual matching instead of directly linked records. Our methods utilized a systematic approach and quantifiable match probabilities to increase accuracy. Matches were checked at random to maximize successful matches and minimize the possibility of inaccurate matching. The direction of bias inherent to probabilistic matching is difficult to quantify; however, it is possible that more-acute patients will have less-complete records because of time constraints or being unable to communicate with health

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care providers. Further, the importance of this methodology and the achieved match rate to obtain outcome data linked to prehospital and PSAP data is essential for future prehospital studies using multiple distinct data sets.

Third, we are unable to comment on a number of MPDS codes because of the low utilization. Finally, there are limits to the external validity of this study that limit the generalizability of the study to other EMS systems, as we included patients transported to two of the five hospitals in the county and do not have outcome information on the excluded patients.

Future studies are needed to validate these findings and investigate the potential systems improvements and cost-effectiveness of these changes to the EMS system and MPDS. These studies would likely benefit from prospective data gathering, pooling of data from multiple institutions/communities, and/or longer study periods.

CONCLUSION

This study demonstrates a strong correlation between specific emergency medical dispatch codes and ED outcomes. The association between specific codes and patient age could be used to improve resource utilization in prehospital and hospital environments. Furthermore, the methods used in this study can be used in a wide range of communities for evidence-based decision making for organization, management, and quality improvement of EMS systems.

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