

## Chapter 4.22

# Predicting Ambulance Diversion

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### ABSTRACT

The high utilization level of emergency departments in hospitals across the United States has resulted in the serious and persistent problem of ambulance diversion. This problem is magnified by the cascading effect it has on neighboring hospitals, delays in emergency care, and the potential for patients' clinical deterioration. We provide a predictive tool that would give advance warning to hospitals of the impending likelihood of diversion. We hope that with a predictive instrument, such as the one described in this paper, hospitals

can take preventive or mitigating actions. The proposed model, which uses logistic and multinomial regression, is evaluated using real data from the Emergency Management System (EM Systems) and 911 call data from Firstwatch® for the Metropolitan Ambulance Services Trust (MAST) of Kansas City, Missouri. The information in these systems that was significant in predicting diversion includes recent 911 calls, season, day of the week, and time of day. The model illustrates the feasibility of predicting the probability of impending diversion using available information. We strongly recommend that other locations, nationwide and abroad, develop and use similar models for predicting diversion.

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## **BACKGROUND**

A majority of Emergency Departments (EDs) across the United States perceive they are at or over capacity (Lewin Group, 2002). As ED visits have been on the rise, the number of hospital EDs and beds available at hospitals has decreased (Nawar, Niska, & Xu, 2007; U.S. General Accounting Office [GAO], 2003). In literature, several authors discuss factors contributing to ED saturation, ranging from high patient acuity and bed shortages (Derlet, Richards, & Kravitz, 2001) to lab delays and nursing shortages (Richards, Navarro, & Derlet, 2000).

When EDs reach their capacity, ED staff is unable to promptly care for new arrivals, and services within the hospitals are unable to accommodate the specific needs of new ambulance arrivals; hence ambulances must be diverted to other facilities that can provide critical care. This situation, referred to as “Ambulance Diversion,” not only results in delays in emergency care (Redelmeier, Blair, & Collins, 1994), but could also contribute to patients’ clinical deterioration (Glushak, Delbridge, & Garrison, 1997). We attempt to develop a mathematical model whereby hospitals/EMS agencies in a region can use 911 calls and diversion status of hospitals to predict the likelihood of the occurrence of diversion.

## **LITERATURE REVIEW**

A study of the literature shows that the rising trend in ambulance diversions started causing concern during the late 1980s (Richardson, Asplin, & Lowe, 2002), resulting in reports, position papers and task forces studying this problem from the early 1990s (Frank, 2001; Vilke, Simmons, Brown, Skogland, & Guss, 2001; Pham, Patel, Millin, Kirsch, & Chanmugam, 2006). However, owing to the elevated utilization level of EDs, ambulance diversion continues to be an issue today

and is a common and increasing event that delays emergency medical care (Redelmeier et al., 1994).

A wide range of literature exists, discussing the problem and various solutions have been suggested. A U.S. General Accounting Office survey (2003) found that while about two of every three EDs reported going on diversion at some point in fiscal year 2001, a much smaller portion—nearly 1 of every 10 hospitals—was on diversion more than 20 percent of the time. A cohort of twenty-two master’s degree candidates from the University of Virginia (2001) did a detailed study on diversion at Richmond hospitals, and outlined problems and solutions, analyzed via a simulation model. A government study (U.S. House of Representatives, 2001), quoting instances of diversion from the local press in all states, reported that ambulance diversions have impeded access to emergency services in the metropolitan areas of 22 states. Vilke et al., (2001) tested the hypothesis that, if one hospital could avoid ED diversion status, need for bypass could be averted in the neighboring facility. They concluded that reciprocating effects can be decreased with one institution’s commitment to avoid diversion, thus decreasing the need for diversion at a neighboring facility. Neely, Norton, and Young (1994) found that ambulance diversions increase transport times and distances. One community served by four hospitals reduced ambulance diversion during a year, by 34% (Lagoe, Kohlbrenner, Hall, Roizen, Nadle, & Hunt, 2003). This was accomplished by sending daily diversion statistics to hospital chief executive officers and ED directors and managers, along with each hospital individually implementing its own measures to reduce diversion hours. Schull, Mamdani, and Fang (2004) found that there was an increase of diversion hours during the months of November and December and correlated it to the effect of flu on diversion. Only two papers in medical literature referred to 911 calls being used in a transport decision. Anderson, Manoguerra, and Haynes (1998) explored the effect of diverting poison calls to a poison center and Neely et

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