PREDICTING AMBULANCE DIVERSION

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ABSTRACT

Although Ambulance Diversion is a major issue in metropolitan communities, no tool exists to predict when it can occur in a hospital. This research involves developing a tool to predict when Diversion will occur in a community, so hospitals can take appropriate steps to avert it. This is achieved by developing and evaluating various causal models, using methods such as logistic regression and Markov models. These models are developed using data from real hospitals and the EMS system of a metropolitan area. Results of preliminary analysis and outline of the research being undertaken is presented.

INTRODUCTION

The nation's approximately 5000 emergency departments are operating at critical capacity. Delays in accessing a hospital bed have become a serious problem in many hospitals. This leads to hospitals diverting ambulances to a neighboring facility that can take patients, a process called Ambulance Diversion.

A tool to predict when this event can occur in a region would go a long way in helping EMS communities to take patients where beds are available, and not waste precious time in transporting critically ill patients. This poster discusses a tool being attempted to predict the likelihood of such an event occurring, using 911 calls, so that hospitals can take steps to free their Emergency Departments and inpatient beds in order to be able to take all patients that arrive by ambulance.

OBJECTIVES

- Establish a relationship between 911 calls and diversion
- Define an approach for predicting diversions in hospitals using causal factors.

METHODOLOGY

Two types of data was collected from Kansas City, MO

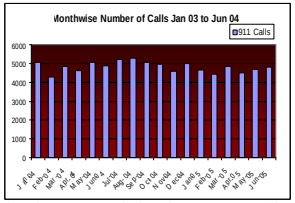
Records of all 911 calls received for a period of one and a half years from January 2003. This includes data on the time the call was received, type of emergency, Clauson code, and if the patient was transported, and if so, to which hospital.

Diversion data entered by hospitals, into "EMSystem" that included when a hospital went on diversion, the duration of diversion and reason. Data from 29 hospitals was studied.

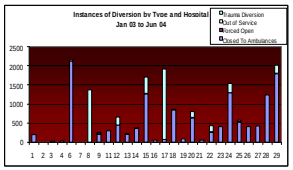
Logistic regression was found to be an appropriate tool to be used. A program was developed in the statistical software "R" to analyze the unique form of data obtained.

RESULTS

There were a total of 166,000 911 calls during the one and half year period chosen. 87,000 of them ended in a transport to a hospital.

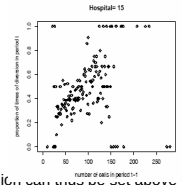


During the same period, at least 25 out of the 29 hospitals went on diversion at some point of time. Hospitals were on diversion for a total of 32,000 hours



A variety of preliminary statistical analysis was performed. Logistic regression proved to be an appropriate choice for analysis since, it was observed that as the 911 calls went up, the probability of a hospital going on diversion increased. The diversion data could be put in any interval and compared with 911 calls in any interval. A two hour interval was found to be the most significant for predicting diversion using 911 calls.

Experiments also revealed that Logistic regression proves to be an appropriate choice for hospitals with significant amount of diversion as the following figure illustrates. Hospital 15 had significant diversions



A threshold regio... which a hospital has a higher probability of going on diversion.

"Its becoming disastrous. We're traveling across town shopping for hospitals"

Tucson Fire Captain, Joe Gulotta

CONCLUSIONS

This research proves that 911 calls can be used as a predictor for Ambulance Diversion. Such a tool would go a long way in helping EMS regions plan effectively for transport of patients, and hospitals to be warned of an impending diversion decision. The comprehensive model will address several other factors to predict diversion besides 911 calls already studied. Although this model is specifically being developed for the EMS system of one region, it is the first attempt of its kind in using Industrial Engineering tools for the healthcare delivery problem of diversion, and it can be used as a reference tool and applied in other EMS systems, by appropriate modifications in the data, and covariates which would depend on specific characteristics of the community that would apply it.

FUTURE WORK

The preliminary logistic model will be modified to consider the correlation between locations of hospitals and 911 calls. GIS mapping will be used to look at effect of locations in a metro area. A multinomial model as follows will be used to consider the joint probability for a collection of hospitals. This will require the construction of Markov Chains. Other covariates like number of beds, variations on type of calls, seasonal effects and other confounding factors will be considered.

$$\mathrm{P}(b_{t+1} = k \mid b_t, x_t) = \frac{e^{m_k(x_t, b_t)}}{\sum_{\ell=1}^{2^H} e^{m_\ell(x_t, b_t)}}, \; k = 0, 1, \ldots, 2^H - 1$$

Once the model is complete, the probability that a particular hospital will be on diversion based on number of 911 calls and other variables can be estimated. It would also be possible to estimate the correlation between a set of hospitals being on diversion and the order in which they would divert.