Root Cause Analysis of Emergency Department Crowding and Ambulance Diversion in Massachusetts

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Executive Summary

Background:

Emergency department crowding and ambulance diversion first became important public health issues in Massachusetts and elsewhere during the late 1980's. Crowding resolved spontaneously, however, as demand for emergency services declined in association with managed care practices introduced during the early 1990's. As economic pressures continued, the number of acute care hospitals decreased dramatically in the Commonwealth while the demand for hospital services reached a nadir in 1997.

Since 1997, demand for emergency services has rebounded to levels not seen since the early 1990s and emergency department crowding has returned as a predominant public health concern. Numerous mechanisms have been suggested as responsible for this, each implying a different (and costly) remedy. From an operations management perspective, all crowding drivers may be broadly classified as problems of input, throughput, or output. These investigations were undertaken to qualitatively identify which of these are operative in hospitals today.

Methods:

This study was conducted in three phases.

Phase I: Using data available from the Massachusetts Department of Public Health, the Division of Health Care Finance & Policy, regional EMS directors, and from field interviews conducted by members of the Variability Program at representative Massachusetts hospitals, a conceptual model was developed of the supply/demand relationships operative in today's acute care hospitals. Special consideration was given

to the interdependence of inpatient and outpatient units and to the variability of emergent and non-emergent demand flows.

Phase II: Two facilities (labeled as Hospital A & B), selected as representative of community and teaching hospitals, were subjected to detailed operational analysis. Patient flow data were collected throughout a six week period encompassing over 6,000 admissions, 8,000 emergency department visits, 2,000 staffing and capacity points, and 300,000 data points related to patient movements. Using this data, three hypotheses relevant to the input, process, and output drivers of ED crowding were tested.

Phase III: A "generic" hospital was modeled in simulation and validity of the model was established through use of Hospital B inputs to the model, followed by comparison of outputs from observational data with the outputs created by the model. Data accumulated in phase II were subjected to online analytical processing (OLAP) and utilized as inputs in construction of patient flow simulation software. The sources and types of variability were analyzed and utilized in establishing the relationships of scheduled and unscheduled patient flows. The resulting product (ED Divert Model©) facilitates understanding of the diversion problem by permitting the user to observe the simulated impact of changes in hospital demand and capacity. As a "generic" hospital model, it provides "proof of concept" but is not suitable for decision-making at a specific hospital.

Hypotheses:

1. The arrival rate of emergency patients is too high, producing diversion status as the ED saturates.
2. The processing rate of emergency patients is too low, relative to arrivals, leading to bottlenecks and diversion status.
3. Emergency arrival and processing rates are manageable, but there is insufficient hospital capacity to accommodate emergency admissions. As a result, emergency department capacity is saturated by in-patient "boarders"
    a. Corollary: Flows of scheduled and unscheduled patients compete for a limited number of hospital beds. Variability in the former creates variability in accommodation of the latter. Demand peaks and diversion may be reduced by controlling scheduled flow.

Results:

- Correlation between the number of ED arrivals and divert status is negative. At the two studied hospitals, the pattern of demand for emergency services does not have a frequent, consistent and reproducible effect on diversion status. As expected, the correlation between arrivals and diversions is negative for both hospitals ($r = -0.141$ and $r = -0.166$) due to the fact that implementation of diversion status modestly decreases arrivals. More importantly, excluding diversion hours from the analysis and analyzing hours immediately prior to diversion yields weak correlations to diversion (range of $r = 0.076$ to $r = 0.167$).

- Correlation between ED census (less ED boarders) and diversion is extremely slight. In the absence of the effect of ED boarders, ED census is not a significant driver or predictor of diversion status for both hospitals ($r = -0.051$ and $r = 0.000$).

- Correlation between ED process time and diversion status is minimal. The duration of patient care in the ED (as measured from the time an individual first enters a treatment slot/bed to the time the patient is ready to leave the ED) is not a limiting factor to the patient throughput (range of $r = -0.133$ to $r = 0.173$). Indeed, when examining overall averages by hour of the day, the opposite was observed: ED care is slightly accelerated during those periods of the day which have the most diversion.

- Correlation between average number of ED patients waiting for hospital beds and divert status was substantially higher than all other tested hypotheses. The high correlation for both hospitals between boarders and diversion strongly suggests that ED diversion status is related to delayed inpatient disposition ($r = 0.426$ and $r = 0.327$). The most straightforward interpretation of this result is that there is at least a relative deficiency of inpatient capacity in both of the studied institutions.

- In an institution where scheduled demand is a significant portion of overall demand, there was stronger correlation between average hourly scheduled admissions and diversions than between average hourly ED demand and diversions when examined by hour of the day. Wide swings in scheduled admissions suggest artificial variability in patient flow. Peaks in scheduled demand affect ED diversions more than ED demand itself. Because scheduled demand is, by definition, controllable, this provides an opportunity to relieve ED congestion.

- The number of scheduled admissions is more variable than the number of admissions through the ED. Although previously neglected in heath care, this counterintuitive pattern suggests that variability control of scheduled admissions may provide a significant opportunity to increase hospital throughput and access to care.

- The **ED Divert Model**© was developed by *the Program* for the purpose of studying the effects on diversion of adding resources to various inpatient areas, increasing flows from various hospital resources, as well as the basic patterns of those flows. Preliminary analyses using the model demonstrate the sensitivity of diversion to the availability of specialized resources such as intensive care or telemetry beds. Under most conditions, adjustments of ED capacity or process time have less impact than smaller adjustments in critical bottlenecks elsewhere.

NOTE: Though intended for distribution as a learning tool, the model is not a representation of any particular hospital and the numbers and patterns incorporated within it, although intended to be realistic, do not represent any real hospital in Massachusetts or elsewhere. In its current state, the **ED Divert Model**© is subject to continued research and refinement towards more robust and generalizable designs. Because the structure and relationships of units within the model are fixed, it is not possible to apply its outputs to specific facilities. For this reason, the model is provided

with the caution that ***is intended for research only and should not be employed as a management decision making tool***.

Conclusions:

The most significant driver of ED diversions in the two hospitals studied is the lack of sufficient inpatient capacity. This is supported both by observational data and by stochastic modeling. Capacity shortfalls may result from either an *absolute* lack of staffed hospital beds, a *periodic* bed shortage revealed during peaks of demand, or a combination of the two. The relative importance of these two factors varies between different hospitals and should be determined based on analysis of the demand and capacity data for both scheduled and unscheduled admissions for each particular hospital. A larger-scale study of the capacity, demand, and variability issues would be necessary to adequately address the root causes of ED diversions in a broader cross-section of hospitals. A more extensive sampling would also permit development of a more robust computer model.

Discussion:

There are three major problems collectively dominating the landscape in health care delivery today: emergency room diversions, nursing overloading/understaffing, and medical errors. The issue of emergency room diversion is well known in Massachusetts, receiving considerable press coverage in recent years. Nursing understaffing and medical errors have received even wider attention nationally, including in the form of recently published reports which provide compelling evidence of links between these two issues. Variability in patient flow affects all three of these problems simultaneously by producing intermittent system overload. Hospitals operating below capacity will easily tolerate variability while those operating near full capacity will undergo serious stress during times of peak demand. Counterintuitively, the number of *scheduled* admissions is more variable than the number of patients arriving through the Emergency Department. When peaks in scheduled admissions take place, many of the hospital's floor and ICU beds become unavailable for ED patients, forcing ED nurses to experience additional workload caring for these patients, thereby endangering the quality of care. This implies that smoothing of elective schedules can provide simultaneous gains in both health care access and quality of care.

A recent implementation of efforts to control inflow variability by capping admissions at Luther-Midelfort in Wisconsin demonstrated the potential benefits of smoothing variability. In this 300 beds hospital smoothing resulted in:

- Emergency Department diversion hours reduced from 12% to 1-2%
- An increase in the number of patients moved from the ED to an inpatient bed within 1 hour from 23% to 40%
- Reduction of nursing vacancy rates from ~10% to 1%.
- Increased annual revenue of nearly $2.5 million (related to capture of lost productivity)

These results, though encouraging, are not sufficient to warrant change in the industry. Further, the particular methods used are not necessarily the best available for application within Massachusetts. Confirmation through a large-scale study, along with implementation of the variability methodology at one or two hospitals in Massachusetts is necessary and should proceed as soon as possible.