Developing H1N1 Hospital Surge "Dashboard" Indicators: A Demonstration

Geoffrey Hoare PhD
Florida Department of Health
geoff_hoare@doh.state.fl.us

Mary Russell, EdD, MSN
Florida Department of Health
Mary_Russell@doh.state.fl.us

Aaron Kite-Powell MS
Florida Department of Health
Aaron_Kite-Powell@doh.state.fl.us

Rick France PhD
Florida Department of Health
Rick_France@doh.state.fl.us

ABSTRACT

Developing key state-wide indicators of Florida's health care system's public health capacity during the H1N1 Pandemic has been challenging. This ***demonstration*** outlines work to develop a key indicator of patient surge caused by the H1N1 outbreak. Further work to calibrate this measure and relate it to surge in other health care organizations is outlined.

Keywords

Situational awareness, surge, hospitals, public health and medical emergency support function, ESF-8, H1N1, Florida

OVERVIEW – DEVELOPING HOSPITAL AND HEALTH CARE SYSTEM H1N1 CAPACITY INDICATORS

The Planning Section's Situation Unit, in the Florida Department of Health's H1N1 Incident Management Team, is improving the situational picture of Florida's health care system's capability, demand for services and surge capacity[1]. The Situation Unit is accomplishing this task by defining factors that drive demand in specific health care service areas or markets. After exploring a number of data sources available for this analysis, the Team developed an initial, key measure of hospital stress that would be appropriate in a situational awareness "dashboard." This immediately useable measure – Total Daily Emergency Department Visits – is explained first. Next, how this measure is being calibrated using other, more complex measures of emergency department capacity is outlined. This is part of a program to create an array of measures of other critical health care system capacity – such as acute inpatient care, sub-acute skilled nursing care and home health care.

Why Focus on Hospitals?

We are currently focusing on hospitals for several reasons:

- ***Prevention and Primary Care*** has been adequately supplied with the distribution of clinical guidance, anti-virals and vaccine.
- ***Weak Link*** – If there are sufficient H1N1 complications that require acute care, hospitals will become the weakest link in the continuum of care.

Reviewing Statement: This paper represents work in progress, an issue for discussion, a case study, best practice or other matters of interest and has been reviewed for clarity, relevance and significance.

[1] Capability is the measure of the *total level* of service(s) that can be delivered by the health care system, or any sub-system or organization. Capacity is the measure of the *current level* of services that can be delivered under specific demand surge and stressed resources.

- ***Higher Mortality*** – Hospitalized H1N1 patients are more likely to die if the hospital is not able to provide adequate care.
- ***Predict and Prepare*** – If overwhelming hospital surge can be predicted, there will be time to set up alternate care sites for low level acute and sub-acute patients. This will ease the surge on hospitals.

Are there readily available measures of hospital surge capacity that don't require getting real time surge status from a substantial sample of hospitals?

Yes. The ESSENCE syndromic surveillance system[2] automatically reports information about hospital emergency department (ED) visits daily. Data from 132 hospitals over the last 12 months covers roughly 75% of all ED visits in Florida. What is different about this effort is that it estimates when the hospitals are reaching capacity.

What data are used and why?

We are using two Syndromic Surveillance indicators in this analysis, *total ED visits* and *ED visits with a chief complaint that was categorized as influenza-like illness (ILI)*. These data are being compared with *EMSystems*[3] *ED Saturation Score* to assess how well it identifies surge conditions. The characteristics of the ESSENCE syndromic surveillance and ED Saturation Score described below – wide participation, large sample size, frequently reported, easy to access – should provide a solid foundation to extrapolate to other measures of hospital capabilities. Future work will use other data sources and models, see Table 1 below.

How can we know when hospitals' EDs are close to their maximum capacity?

We currently do not have good data about the total number of ED visits each hospital is **capable of delivering** per day or week. In its place we make an assumption that hospitals operate with small profit margins, in a competitive labor market. **Therefore they do not overstaff any part of the hospital, including the emergency departments**, because, at the margin, they would probably use expensive, contract employees to do this. Given this assumption, we just need to estimate what amount, above normal levels and below expected capacity, hospitals staff to and how much surge capacity these staffing levels can manage.

Control Limits

A control limit is a useful concept to determine the *normal variation* in the demand for ED care. Control limits are used to analyze the stability of work processes or other systems that fluctuate over time. Upper and lower control limits (UCL, LCL) around the normal variation in a process can be set at any value. Commonly, they are initially set at 3 standard deviations around the mean of the indicators measured for each time period. This would indicate that 99% of the measurements of a system would fall within the upper and lower control limits[4].

Using Exponentially Weighted Moving Average (EWMA) Control Charts

A control chart can be created, with the kind of data available from ESSENCE[5], using an exponentially weighted moving average (EWMA)[6]. The ESSENCE Exponentially Weighted Moving Average (EWMA) model takes data,

---

[2] A description of ESSENCE is at http://www.doh.state.fl.us/Disease_ctrl/epi/Acute/systems.html#ESSENCE; reports using ESSENCE data are at http://www.doh.state.fl.us/disease_ctrl/epi/swineflu/Reports/reports.htm and pp 4-5 in http://www.doh.state.fl.us/Disease_ctrl/epi/Epi_Updates/2009/December2009EpiUpdate.pdf. Syndromic surveillance explained at http://www.cdc.gov/mmwR/preview/mmwrhtml/su5301a3.htm; with definitions at http://emergency.cdc.gov/surveillance/syndromedef/word/syndromedefinitions-intro.doc.

[3] EMSystems' EMResource hospital emergency room capacity reporting system will soon be used by great majority of Florida hospitals. http://www.emsystem.com/info/emresource.html

[4] For examples of run charts with control limits see http://intqhc.oxfordjournals.org/cgi/content/full/19/4/187,

http://www.health.qld.gov.au/quality/docs/vladdummiespresent.pdf, Hospital Adverse Events and Control Charts: the Need for a New Paradigm, Morton, et al, 2009, http://www.sciencedirect.com/science?_ob=MImg&_imagekey=B6WJP-4X9V2RP-7-1&_cdi=6884&_user=1988606&_orig=search&_coverDate=11%2F30%2F2009&_sk=999269996&view=c&wchp=dGLbVtz-zSkWz&md5=ccaced1fb469db72d1aa0c8e38a9c45d&ie=/sdarticle.pdf

[5] A time series with one value for each time period versus a number of events during each time period.

[6] See EWMA Control Charts http://www.itl.nist.gov/div898/handbook/pmc/section3/pmc324.htm

like the Total Number of ED Visits and allows alerts to be set when certain parameters, or upper control limits, are exceeded. The model, in Figure 1, uses an EWMA algorithm, with a 180 day (6 month) baseline, 2-day lag, 0.6 smoothing coefficient and alerts defined as a p-value less than or equal to 0.001.[7] All of these parameters can be manipulated to focus the analysis of the variation in the number of ED visits. The ESSENCE EWMA example in Figure 1 generated alerts during the 2009 winter's normal flu season, as well as, the April spike and the September-November "2nd wave" in H1N1 cases.

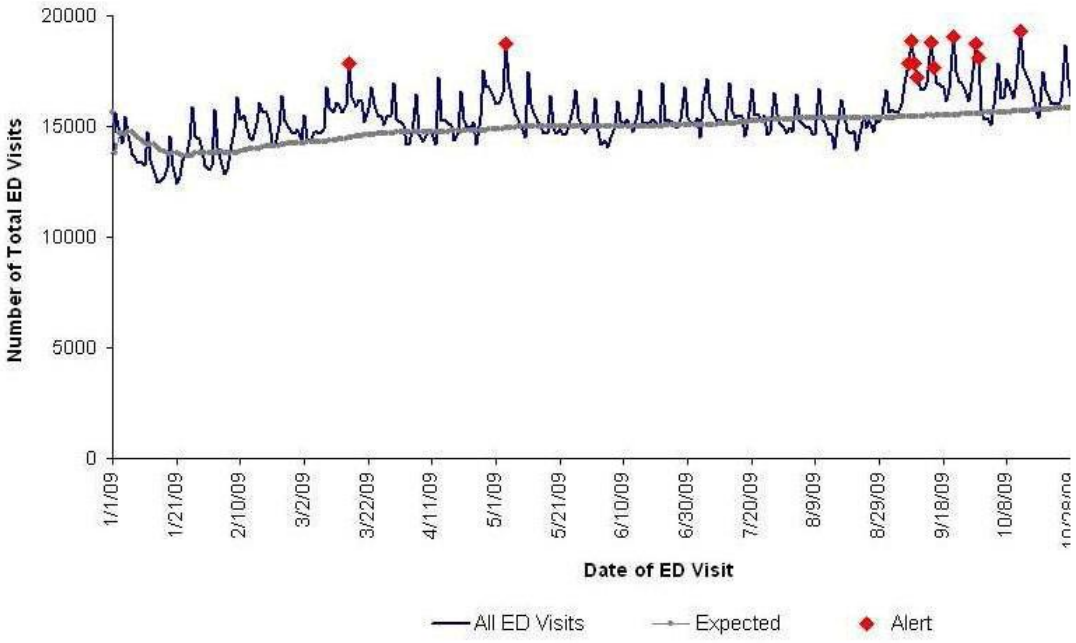

Figure 1: ED Surge Alerts Based on an Exponentially Weighted Moving Average of Total ED Visits, 2009

Identifying Surge Events and Calibrating the ESSENCE EWMA

Retrospective analysis of a sample[8] of hospitals is necessary to determine whether the parameters in the ESSENCE EWMA would have identified when the hospitals experienced surge during this H1N1 outbreak. In particular, the p-value will be adjusted until it creates an alert when surge levels measured by other indicators were reached.

To do this other measures of surge are needed. There are a number of measures to choose from. Input measures include:

- number of patients in relation to the total bed capacity that day,
- number of staff in relation to the total patients that day,
- acuity of patients – which affects the staff to patient ratio needed for quality care,
- available space,
- availability of other scarce resources – vents, negative pressure rooms.

Output measures include:

- EMS Unit wait times,

[7] Model overview http://isds.wikispaces.com/file/view/Burkom_NSSC2008_02Dec08.PPT; Burkom, "Development, Adaptation, and Assessment of Alerting Algorithms for Biosurveillance," Johns Hopkins APL Technical Digest, Vol 24, # 4 (2003), model at http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.134.688&rep=rep1&type=pdf.

[8] Initially this is a convenience sample.

- patient wait times,
- patients waiting to be admitted to the hospital.

Fortunately there is a composite measure developed by EMResource users that is currently being used in several of the State's seven Domestic Security Task Force Regions.

EMResource "Emergency Room Saturation Score"

The ***Emergency Department Saturation Score*** is a capacity measure that was originally developed by emergency department personnel for EMSystems' emergency department status tracking system known as EMResource.

The ten variables used to calculate of the ***ED Saturation Score*** and their relationships, are outlined in Figure 2. The Saturation Score compares:

- ***service demand***

  to,

- the ***total capacity of the ED,***

Service demand – is estimated by the *number of ED beds occupied, patients and EMS units waiting* to be seen, the *number of patients waiting to be admitted* to the hospital, *patients' acuity* and *nurse shortage* of staff. The **total ED capacity** is estimated by the *number of assigned (staffed) ED beds* and *reasonable lobby capacity*.

We are comparing the ESSENCE EWMA score of Total ED Visits outside of an upper control limit to various levels of the ED Saturation Score at a sample of hospitals.

Emergency Department Saturation Score

	Indicator			Capacity Elements	
A1	Number of ED beds occupied	40	A2	Number of Assigned ED Beds	35
B1	Number of patients in lobby	20	B2	Reasonable Lobby Capacity	25
C1	Number of EMS patients waiting or en route	4			
D1	Number of Admits (non-ICU; non 1:1) waiting in ED	6		**Saturation Score**	142%
D2	Number of ICU admissions waiting in ED	2			
D3	Number of patients requiring 1:1 care waiting in ED	2			
E1	Lobby wait time > 4 hours (NO=0 or YES=2)	NO			
F1	Number of RNs short staffed	4		* RN Short Staffed Weight Calculation	5

Version 2.3; 12/31/09

Status Categories [Used by RDSFT 5]

> 0% <100%: ED is running at capacity	Green
> 100% < 150%: ED is running above capacity	Yellow
> 150%: ED is running above capacity	Red
Closed	Black
Not Reporting	Purple

Definitions

Saturation Score = ((A1+B1+C1+D1+(D2*2)+(D3*3)+(+2 if E1=Yes)+F1)) / (A2+B2)

A1 **No. of ED Beds Occupied**—actual # of beds currently occupied in the ED at the time the form is being filled out.
A2 **No. of ED beds assigned:** # of beds that are staffed (Does NOT include overflow hall beds unless they are staffed)
B1 **No. of Patients in Lobby:** # of patients (not including visitors) who are currently waiting in the lobby.
B2 **Reasonable Lobby Capacity:** # of patients that WR can hold under normal conditions (usually ~ 50% of assigned beds)
C1 **No. of ambulance patients en route or waiting**—includes those on the way or already arrived & waiting to be turned over to staff.
D1 **No. of General Admits: #** of patients that are waiting in the ED to be admitted (does not include ICU pts or 1:1 pts)
D2 **No. of ICU Patients:** # patients who are waiting in the ED for ICU admission
D3 **No. of pts requiring 1:1 care: #** of patients that require dedicated 1:1 nursing care (does NOT include ICU or 1:1 care)
E1 **Lobby Time > 4 hours: i**f any patient experiences a lobby wait time of > 4 hrs, check the box. If wait time is < 4 hrs, leave the box blank.
F1 **Number of RNs short-staffed**—the number of RNs the ED is down from normal staffing level.

* If ED assigned beds is 1-15, add 5 points for every 1 nurse that dept is short
* If ED assigned beds is 16-30, add 5 points for every 2 nurses that dept is short
* If ED assigned beds is 31-45, add 5 points for every 3 nurses that dept is short
* If ED assigned beds is >45, add 5 points for every 4 nurses that dept is short
* **Note:** When ED assigned beds is >15, do not add the next 5 points until the next full amount of nurses you are short staffed

Figure 2: EMResource Emergency Room Saturation Score[9]

[9] Note that although stated as such, the score is not a percentage, in that the factors measured in the numerator and the denominator are not the same. Whether the score corresponds to a percentage of ED capacity is being investigated.

Further Validation of ED Surge with Other Data and Extrapolation to Other Hospital Surge Capacity

Once validated, in order to use these ED surge measures to estimate the impact on the health care system's capacity, other ED characteristics are needed. At least three factors determine the impact of a surge or the ability of ESF-8 to support the ED with other resources:

- ED size or daily volume – a "saturated" small ED will have less area impact than a "saturated" large ED,
- patient acuity level the ED can readily treat[10],
- case mix by patient age and/or specialty service needed – for example, pediatric services requiring staff which could be in short supply.

With these, total ED capacity in a health care service area can be estimated.

There are a number of other organizations that supply this information, which could improve our understanding of hospital surge. These sources, their uses, value, availability and cost are summarized in Table 1. For example, the CMS Survey Agency[11] in Florida, the Agency for Health Care Administration (AHCA) gathers data from all acute care hospitals about their total ED visits and inpatient discharges[12]. When available, a retrospective analysis comparing ESSENCE indicators with an array of sentinel ED visits and/or inpatient discharges, would further determine the validity and reliability of using the EWMA model with other ESSENCE data[13]. Besides the EWMA model described here, the Situation Unit has been assessing the usefulness of several CDC projection models – FluSurge and FluAid, as well as Panalysis[14]. These can also be validated with the data described in Table 1.

Data and Source	Use	Cost/ Value/ Availability
Total Hospitalizations from ED [Current time period] Total Hospitalizations From ED w ILI [Current time period] **ESSENCE**	This will allow real time measures of hospitalizations. Allows relating sentinel syndromes to hospitalizations. By age group.	Low cost. High value Real time. Available when sample size the same for 52 week comparison period.
Total Hospitalizations w/ H1N1 [Current time period] Total Hospitalizations [Current time period] Total Hospitalizations with underlying conditions [Current time period] Total Hospitalizations to ICU [Current time period] **Merlin Case Reports**	Under-reports, but adds to quality of complications rate calculation. Validate with ESSENCE data. By age group and race.	Low cost. High value Short lag time.

[10] Trauma center level could be a surrogate of this.

[11] The Federal Department of Health and Human Services (DHHS) Centers for Medicare and Medicaid Services (CMS) requires a survey agency in each state [http://www.cms.hhs.gov/SurveyCertificationGenInfo/] to gather extensive information about hospital, and other health care organizations', utilization. http://www.cms.hhs.gov/home/rsds.asp

[12] Discharges are used instead of admissions because the data is more complete at that time. See AHCA ED Visit or Inpatient Discharge data in Table 1 and http://www.floridahealthfinder.gov/researchers/researchers.shtml#

[13] Such as Total Admissions from the ED.

[14] http://www.upmc-biosecurity.org/website/resources/publications/2008/pdf/2008-04-03-panalysistoolpanplanning.pdf

Data and Source	Use	Cost/ Value/ Availability
Total Hospitalizations [previous year(s) time period] Hospitalizations of Sentinel Diagnoses [previous year(s) time period] Total ED Visits [previous year(s) time period] ED Visits by Sentinel Diagnoses [previous year(s) time period] **AHCA Inpatient Discharge and ED Visit Data**	Validate with ESSENCE data. By age group. Can target and possibly explain complications and what is under-reported in Merlin hospitalizations. Can also be tied to analysis of specific hospital and regional service areas.	Modest cost to gather and analyze. High Value Lags by at least 6 months.
Bed, personnel and key resource availability **AHCA ESS**	*Potential* for real time measures of hospitalizations. Can be related to other ED and hospitalization measures above. Can be used to validate these syndromic and case reported data after an event.	Low cost. Some fields need to be added. High value Low availability, only used in disasters. Low response rate.
Bed availability data. Personnel and key resources could be reported in future. **HAvBED**	*Potential* for real time measures of hospitalizations. Can be related to other ED and hospitalization measures above. Validate these syndromic and case reported data after an event.	Low cost. Medium value Not now available with actionable info needed for H1N1. High potential for future use.
ED Capacity and inpatient bed, personnel and key resource availability data. **Local Response Partners/ Stakeholders (eg. Disaster Councils)**	*Potential* for real time measures of hospitalizations. Can be related to other ED and hospitalization measures above. Validate these syndromic and case reported data after an event.	Moderate cost to work with disaster councils or sentinel hospitals to develop. Hight value Readily available in some locations.

Table 1: Data Sources, Uses, Value and Cost

CONCLUSIONS

Work with this initial indicator is promising. It is an efficient repurposing of a widely used surveillance system. The growing participation of Florida hospitals in ESSENCE and EMResource creates the potential for generating situational awareness at the facility, health care system, county, health care service area, RDSTF and State levels.