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Queue Fever, Part 1

A little number crunching can show hospitals how many beds and staff members they really need.

By David Ollier Weber

Tuesday
April 11, 2006

David Ollier Weber

Editor's note: *This is the first part in a two-part series on handling patient flow. Today the author discusses how mathematical formulas can help manage patient peaks and valleys. Next week, he will show how some variation can be smoothed out simply through better time management.*

$N = \lambda T$. That's a good one, huh? Basic. It's called Little's law, and it enables hospital or clinic administrators to figure out how many patients (N) can be served when λ is their average arrival rate and T is the average total time each one spends waiting and being seen by caregivers.

Then there's the Poisson distribution that describes the probability of unscheduled patient arrivals in any interval of time--the next 10 minutes, an hour, three hours, whatever:

$p = (\lambda)^n e^{-\lambda} / n!$

Umm . . . you seem to be nodding off. Those formulas are just so much gibberish, you say. You don't need any stinking formulas. Like many health care leaders, you're a people-person, intuitive, a brainstormer, a benchmarker.

Too bad. Really too bad. Those and similar equations are the theoretical backbone of many businesses like yours, in which random customer demand must be balanced against fixed capacity. These businesses include airlines, banks, telephone companies . . . indeed, the Internet could not exist without the application of such formulas. They're the fundaments of what's known as queuing theory.

But, as usual, your sector is only belatedly catching on to the one tool that can guide you through the problem that lies at the heart of *all* your problems--how to juggle staffing, beds and financial resources to match constantly fluctuating patient flows.

Quantifying Traffic Flow

Queuing (also spelled queueing) theory traces its origins to the Copenhagen Telephone Exchange at the turn of the 20th century. A brilliant young mathematician named Agner Erlang was employed to calculate how many circuits and operators would be needed to handle a given volume of telephone calls at an acceptable connection rate. (At the time, operators had to manually plug a jack into a switchboard.)

Erlang's 1909 paper "The Theory of Probabilities and Telephone Conversations" laid the groundwork for the modern telecommunications and computer industries. He was honored for his pioneering insights into how to deal with queues--waiting lines that can form unpredictably, whether made up of packets of electrons, restaurant diners, bank depositors, travelers or emergency room patients--by having a statistical unit named after him: the erlang. The erlang, a measure of traffic, can be used to gauge the adequacy of resources allocated to a system.

Eugene Litvak, an amiable professor of health care and operations management at Boston University, director of its Program for the Management of Variability in Health Care Delivery and an adjunct professor at the Harvard School of Public Health, remembers some years ago asking the head of a large emergency department why the hospital didn't apply queuing theory to figure out the level of resources needed to handle unpredictable patient arrivals.

“Thank you very much, Dr. Litvak,” the physician responded.

Litvak was startled. “For what?” he asked in the accent, rich as a plump piroshki, that attests to his origins and his doctorate in operations research from the Moscow Institute of Physics and Technology.

“Thanks for assuming,” the executive smiled, “that I’d know what you’re talking about.” He hadn’t a clue.

A Powerful Tool

Ten years on, not much has changed. At least, laments Litvak, not in the upper echelons of health care. But in conjunction with the Institute for Healthcare Improvement, he is now “trying to the best of my ability to create a certain community [of people conversant with the principles of queuing theory] to be educators at their own organizations.”

On a recent weekday morning, 36 health system representatives from 20 states, Canada and New Zealand wrapped up what they’d learned from Litvak in an IHI-sponsored, three-session, Web-*cum*-telephone seminar titled Queuing for Clinicians. They took turns describing a local patient flow issue to which they’d applied the queuing formulas he’d taught them.

Litvak patiently analyzed their scenarios and offered challenges such as, “Why don’t we think about whether queuing theory can apply at all here? You have to have a random demand. So . . . is your discharge activity random? I’d suggest not. Random demand is not a good thing, and discharges *should not* be random. Many hospitals schedule them. Couldn’t you?”

Litvak has trepidations about the damage that might be wrought by introducing so complex and heavily mathematical a discipline as queuing theory to an audience of health care managers--desperate, fad-prone and likely to swallow it half-chewed.

“There are probably 40 models” based on different queue management goals and service conditions, he explains, “so it’s better to be ignorant than to apply the wrong model.”

Still, for decision-makers struggling to pinpoint the exact number of beds, technology and personnel they need to cope with the vicissitudes of birth, contagion, human decrepitude and violence, “queuing models,” exclaims Litvak, “are the *only solution!* There are no other ways one can figure out the capacity needed given random demand. So to people who say they don’t like formulas, I say, 'Then you don't like figuring out your problem.'

"That doesn't mean," he adds quickly, "that the hospital CEO needs to sit and learn lambda [how to use the formulas]. But he should know queuing theory is available and hire the right people. This is a powerful tool. It really performs miracles."

***Next week:** Math averse? Don't despair. Before you'll ever need to apply queuing theory, Litvak promises you can eliminate most of your patient flow problems by attacking the* predictable *peaks and valleys.*

Queue Fever, Part 2

By David Ollier Weber

While mathematical formulas can help manage irregular patient arrivals, hospital leaders can make even greater improvements by evening out the scheduled procedures and processes.

David Ollier Weber

***Editor's note:** This is the second part in a two-part series on handling patient flow. Last week, the author discussed how mathematical formulas can help manage patient peaks and valleys. Today he shows how some variation can be smoothed out simply through better time management.*

"Every single hospital CEO says 'I need more beds,'" observes Eugene Litvak. "I was doing my own study, and I said to them, 'OK, suppose I would like to give you more beds. Tell me how many . . . telemetry, med-surg . . . how many more beds do you need? Give me a number--10, 50, 100?' They couldn't. They don't know."

It was the same story when Litvak, a Russian-trained professor of health care and operations management at Boston University, director of its Program for the Management of Variability in Health Care Delivery and an adjunct professor at the Harvard School of Public Health, queried HMO executives.

"They all said, 'Hospitals have a lot of fat. Let's slash that fat.' So I asked them, 'OK, how many beds should we take out? Give me a number.' They couldn't. They don't know."

Yet there is a methodology for settling such questions with great precision, Litvak points out. It's called queuing theory--a set of densely notated mathematical formulas for analyzing streams of input, whether they're the data packets that make up telephone calls, the travelers waving tickets at harried airline boarding clerks or the tableless diners cooling their heels in restaurant bars. Indeed, virtually every industry--except health care--in which success or failure rests on adjusting finite capacity to infinitely variable customer demand has long since embraced queuing theory.

"In health care," scoffs Litvak, "we believe that experience and feeling are the way to manage. No! When we had unlimited cash flow that may have been fine. We used to staff to the peak of demand. But we no longer have the resources."

Determining the basic complement of beds, physicians, triage nurses and all the other personnel and paraphernalia essential to the optimal functioning of an emergency department around the clock, for example, "is a classic problem for queuing theory," he declares. "Executives say, 'We don't want formulas!' Well, unfortunately we have to use them. And the sooner health care recognizes that, the more patients' lives will be saved . . . not to mention millions of dollars!

"Hospitals are making a big mistake if they don't employ this methodology," he adds. "It would be a big story-point to legislators, payers . . . everybody! Hospitals could say, 'Here are the calculations. Now, if you don't want to give us the resources we need, the responsibility is on you.'"

Managing *Non*-Random Demand

Even while he's proclaiming the extraordinary power of queuing theory, Litvak warns that it must not be applied indiscriminately. Queuing theory is an ideal tool for determining resources for *random* demand, he reiterates. Most of the peaks and valleys in patient flow that plague hospitals are not random at all, he emphasizes.

"If you can't staff to peaks, why have peaks?" he challenges. "Hospital people will answer that they're given by God. Not true! We create peaks artificially. That's what needs to be fixed first."

"No matter what you do [to eliminate overcrowding, waiting times and ambulance diversions] in your ED," he told a group of health care executives enrolled in a Web-based Queuing for Clinicians seminar he taught under the aegis of the Institute for Healthcare Improvement earlier this year, "put me in charge of your elective surgery schedule and I'll bet I can destroy everything you build."

Case in point: St. John's Regional Health Center, an 886-bed nonprofit hospital in Springfield, Mo. As at many, if not most, hospitals, the 32 operating rooms at St. John's were scheduled to full capacity in 2002. Christy Dempsey, R.N., vice president for perioperative and emergency surgery, knew that emergency cases from the 45-room trauma center accounted for at least 20 percent of the 29,000 surgical procedures performed annually. But, of course, each had to be squeezed in *ad hoc*--last-come, first-served. That meant bumping scheduled patients, often forcing them and their surgeons to wait hours for an available OR, operating after 5 p.m.--even at 2 a.m.--with hours and hours of unplanned overtime for staff.

Working with Litvak, Dempsey set out to tame this queuing problem. She began by dedicating a single OR to overflow surgeries. Although surgeons initially grumbled because the one fewer room reduced their capacity to schedule procedures when they wanted, they found after a year that they had been able to increase their workload and boost their revenues proportionately. Moreover, the number of OR rooms needed after 3 p.m. had been cut almost in half. Surgical volume has continued to rise at St. John's by 7 percent to 11 percent each year.

But there were still huge swings in patient census, Dempsey noted, especially for orthopedic surgeons, who perform many elective procedures. They booked their allotted ORs solidly from Tuesday through Thursday for their own convenience. As a result, orthopedic patients had to be shuttled off to recover in an inappropriate unit some 17 percent of the time.

In 2004, Dempsey persuaded the orthopedic surgeons to schedule elective procedures evenly throughout the week. That too was an unpopular initiative until the surgeons calculated at year-end that they'd gained 19 hours of OR block time, and other surgical specialties had benefited as well. Meanwhile, the number of patients who had to be accommodated on a medical rather than an orthopedic floor--with cascading consequences throughout the hospital--dropped to less than 4 percent.

"The OR is the driver of variability because there's so much fluctuation in the elective surgery schedule," declares Dempsey. By leveling its *controllable* peaks and valleys, she says, St. John's has seen patient satisfaction soar along with revenues, quality of care and safety. Now she's quantifying how the removal of this central bottleneck has affected departments upstream and downstream.

Dempsey didn't have to plug numerical values into Greek letters in any fancy equations to make major inroads into her hospital's artificially created queues. (Although she did have to do a lot of rigorous preliminary data collection.) Neither did Deb Bell-Polson, R.N., interim director of maternity and childbirth services at Elliott Hospital in Manchester, N.H., when she and the former director smoothed out prickly queues created by doctors' and midwives' insisting on scheduling all induced and Caesarian births at 7 a.m.

Under Litvak's tutelage, they declared that half the hospital's eight L&D beds would henceforth be reserved for the natural--thus unpredictable--labors that were disrupting patient flow. They also asked the OBs and midwives to spread their scheduled deliveries more evenly throughout the day. Result: skepticism, then grudging recognition that ebbs in random traffic freed up beds for standby C-sections and induced labors followed by fewer last-minute postponements, fewer ruffled feelings and, finally, less staff stress.

"It's going wonderfully," summarizes Bell-Polson.

Hospital-Specific

Litvak cautions that these specific initiatives to eliminate factitious queues should *not* be benchmarked. "Each hospital has to decide what's right for them," he says, "based on hard data."

To drive the point home, he compares two hypothetical medical ICUs, one with five beds, one with 10. Suppose they have identical patient acuity, the same average length of stay (2.5 days) and identical patterns of arrival scaled to size (1 patient per day for the smaller, two patients per day for the larger). Would they have the same likelihood of filling beyond capacity and having to turn away patients?

No. The larger can afford a much higher utilization rate, Litvak demonstrates through queuing theory. So for either hospital to benchmark on the other would be a serious mistake.

Queuing theory is an invaluable flow-management tool that has been ignored for all too long in health care, Litvak stresses. It can readily provide answers to service quandaries that stem from truly random fluctuations in baseline demand.

But all too many of the clogs in the service pipeline that cause disruptive trickles and spurts are of a hospital's own doing. So, he counsels, *subtract* them from the pipeline first. Then apply the higher math.

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This article 1st appeared on 2006-05-01 in HHN Magazine online site.

H&HN is published by Health Forum, Inc.
an American Hospital Association information company.