EMERGENCY PHYSICIANS MONTHLY

Little’s Law: The Science Behind Proper Staffing

1 COMMENT

Length-of-stay (LOS) is quickly becoming a key metric of focus for our EDs. This is even truer with the inclusion of LOS into CMS’s core measures list. The importance of understanding LOS cannot be overstated, given that it is instrumental in determining the number of ED beds you need. This treatise is simply an overview of a little known law called “Little’s Law” and how to use it to gain new insights into managing your ED.

Little’s Law is a simple but elegant construct which all ED managers should understand. The “law” states that the Lead Time = Work-in-Progress (WIP) ÷ Production Rate (PR). In non-service industries, lead time is the time it takes to fully complete a widget. For example, if you can produce 20 widgets/hr, the lead time would be 3 minutes/widget on average. Thus, if your lead time is spiraling out of control, you have the choice of either decreasing your work-in-progress (i.e., slow the assembly line) or by increasing your production rate (add more workers or improve existing workers productivity).

In healthcare, where, with all due respect, the widget is a patient, you cannot decrease the work-in-progress (i.e., “patients-in-progress”) when lead time (i.e., length-of-stay or LOS) spirals out of control. We are charged to see all patients, as soon as possible, despite the resources at hand. Thus, the only way to bring the LOS back in control is to either add staffing to meet demand or to increase provider productivity. As an example, let’s say you work for a hospital which is demanding that you maintain a LOS of 3 hours (180 min). If, on average, at any given time over the busiest 8-hours of the day, you have 30 patients on average in your department (i.e., work-in-progress), based on Little’s Law, every server in your ED (physician, RN, bed, lab, X-ray, etc.) must process 10 pts/hr in order to keep pace with the demand. The actual staffing requirements for any server would be dependent upon that server’s mean productivity rate. For example, if your average physician productivity was 2.5-patients/hr, you would need at least 4 physicians on duty to keep pace with the demand (10 ÷ 2.5 = 4). Likewise, if your RN productivity was 0.8 pts/hr, you would need 12.5 RNs (10 ÷ 0.8 = 12.5) to meet the demand, and so forth. Unfortunately, this is only part of the story. The rest of the story requires us to examine the basic tenets of queuing theory.

Queuing theory is the study of waiting in lines. A queue is a group of people or things waiting in a line to be processed, such as patients waiting in the ED. In queuing theory, a simple queue is defined as a situation where a server (a physician, nurse, bed, hospitalist, X-ray, lab, etc.) is providing some service to arriving patients. In fact, the ED can be viewed as a serially-linked network of queues (i.e., multiple servers providing some form of service to each arriving patient in succession). If the patient demand exceeds the capacity of any one of these servers individually, a “queue” will form. The truth is that your ED will perform only as well as its slowest server. Nonetheless, in the example above, Little’s Law predicted we needed a production rate of 10 patients/hr to maintain the LOS at 3 hours. Also, we intuited that if our physician productivity was 2.5 patients/hr, we would need 4 physicians to staff the ED during this timeframe. However, this would only be true if there were no variation in the arrival pattern of patients and no variation in the physician's service times. To understand this better, let's take a moment to examine both types of variation and their effects on provider staffing.

Arrival Variation

Let's say that between 1 and 2 PM you see an average of 8 patients per hour in the ED. How well can you rely on that average for staffing purposes? Siméon-Denis Poisson, a 19th century French physician-mathematician, came up with a probability distribution to address just this issue – the probability of a number of events occurring in a fixed period of time if these events occur independently with a known average rate. His formula suggests that you will see your average 8 patients per hour only 14% of the time. 13% of time, he predicted 9 patients would arrive, and 10% of the time, 10 patients would arrive, and so forth. Thus, if you staffed your ED for the average, you would, by Poisson's math, be understaffed at least 23% of the time. Thus, you must have a little extra provider coverage to keep the LOS in check.

Provider Variation

Additionally, variation in provider service times must be considered when developing effective staffing solutions. For example, if on average, the physicians in your group see 2 patients/hr, this means they generally spend 30 minutes total time on any given patient (all in). This includes everything from getting the chart to talking to pre-hospital providers about their interventions to performing the history and physical to writing and following up on orders. However, what happens to the department if you have to spend 45 minutes on a particular patient? What about 60 minutes? The bottom line is that if your staffing model is based upon an average 30-minute service time per patient, then on those patients where you exceed that time frame, a queue will form.

The punch line is that in order to maintain a LOS at 3 hours, you must incorporate additional staffing (generally somewhere between 10-20%) or increase their productivity (by 10-20%), beyond that predicted by Little's Law, to account for Poisson arrival and service time variation. The actual calculations for determining this are beyond the scope of this article and require specialized queuing-based software.

Lastly, let's look at another translation of Little's Law (Lead Time = WIP/PR). This translation states that, for any given server, the Cycle Time = WIP ÷ Production Rate. Here, cycle time is defined as how long it takes for a given ED server (RN, physician, bed, lab, etc.) to process a patient. Work-in-Process, in this sense, is the number of patients that a particular server is caring for at any given moment. Let's say, for example, the productivity rate of your main ED nurses is 0.8 patients/hr (very good) but they are severely understaffed. Innocently, your hospital administration, being frustrated with the department's LOS, asks you to add more provider staff hoping that this will ease the situation. After performing a queuing-based staffing analysis, you appropriately add the correct number of physicians to meet the demand, but the RN staffing model remains unchanged. Paradoxically, this action will result in an increase in your LOS! How is that possible? What happens is the increased horsepower in your physician server now forces more work-in-progress for the already burdened nursing staff to manage. The net result is that any reduction in your LOS realized by improving the physician cycle time is abolished by an even greater increase in the nursing cycle time due to both an increase in the work-in-progress and a reduction in their productivity caused by stretching them even thinner (a double insult). The bottom line is the RN and physician staffing models must be balanced or you will see a paradoxical worsening of your departmental queuing metrics.

In summary, Little's Law provides a general framework for understanding the complex relationship between ED staffing and LOS. Additionally, ED directors need to understand that slightly more staffing will be needed, beyond that predicted by Little's Law, given Poisson arrival and variation in provider service times. Lastly, adding coverage to an unbalanced staffing mix only worsens the LOS pursuant to a victimization of your under-capacitated server.

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1 COMMENT

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Little’s Law is named for its inventor, John DC Little, one of the formative voices in operations research/management science/analytics, a field that is being applied more and more to problems facing the healthcare system.
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