Improvements in the Emergency Dept.: Understanding and Managing Computer Simulations

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Changes to any emergency department— large or small, rural or urban, busy or, well, busy—cause numerous and sometimes unforeseen consequences to healthcare delivery. Whether change is deliberate or is visited upon a provider from outside forces, it will impact patients, staff and the community. Computer simulations offer a safe and cost-effective way to experiment with changes to processes, staffing and even the footprint of a department or entire hospital. In this way, simulations guide administrators in making the best decisions for their facilities.

Computer modeling and simulation allows one to evaluate a number of scenarios for delivery of emergency care, over time and with any number of variables. Software can create a "virtual ED" of an existing or planned ED, with scaled-to-size walls, equipment, moving staff and patients on gurneys.

Common goals for using computer simulation for emergent care are to:

- compare an existing emergency department (ED) floor plan to a proposed renovation
- study emergency room design for new construction
- contrast one workflow with another to increase throughput and/or patient satisfaction
- analyze changes in staffing, square footage and/or number of beds
- predict the impact of demographic shifts in the patient population over time
- examine the effects of increased or decreased competition
- anticipate the impact of internal changes such as increasing or decreasing inpatient beds, laboratory staff or equipment, ED physicians, etc.

Computer simulation software can be either customized or off-the-shelf. However, because the data collection required for a thorough simulation is labor intensive, analysis of important human variables demands specialized expertise and creating actionable outcomes requires experience. Healthcare providers typically rely on an outside consultant to guide them through the process, to run simulations from start to finish, or both.

Why is computer simulation better than other methodologies?

Of course, real-time, on-site experiments to improve delivery of care would have extreme consequences in an Emergency Room. As an alternative, almost any paper and pen analysis of such experiments would be preferred. Like computer simulations, such analyses could capture on some level changes to workflow, for example, with little impact on staff, no impact on patient safety or satisfaction, and comparably little cost.

Computer simulations offer these advantages, plus other important benefits.

Charting complex human interactions

For many years, hospitals and other organizations in the service industry adopted the factory-based models to evaluate processes. But patients are not widgets, and factory workers do not typically

need the same complex problem-solving skills of clinicians. So the familiar clock-watch evaluation of factory workflow does not account well for the complexities of patient-family-clinician interactions, the role of ancillary departments or the multi-tasking required of nurses and doctors in the emergency room setting.

The numerous factors that impact busy EDs are best captured by computer models. Once data is collected, administrators can test and view quickly and easily the impact of any number of variables, even those related to productivity based on the experience level of clinicians.

Change happens before their eyes

The benefit of a computer simulation continues with a deliverable such as the three-dimensional (3-D) on-screen visualization of patient throughput, for example. With computer-aided design software, both the administrative decision-makers and the front-line staff see, most literally, the impact of changes to the ED workflow and throughput.

Instead of data-heavy charts and statistics, stakeholders watch their own virtual ED transform and improve based on changes to the model. Since any changes to actual workflow will impact both caregiver and patients—often with reduced productivity at first—computer simulation goes a long way to creating advocates vs. detractors during the transition period of implementation.

With computer simulations, stakeholders watch their own virtual ED transform and improve based on changes to the model, including changes they may suggest.

What types of changes can ED simulations capture?

Computer simulation can help decision-makers to experiment with changes, compare options and simply to evaluate limitations in:

1. *Existing Emergency Departments* that are experiencing long wait-times or unsatisfactory throughput because of an increase in patient populations or bottlenecks in other areas of a healthcare facility, for example.
2. *Planned renovations and entirely new EDs,* to identify problem-areas months before the first construction vehicle arrives on the scene.
3. How workflow and floor plans will *function over time relative to macroenvironmental factors* such as population shifts and competitors' market share *and microenvironmental factors* such as changes in staffing or addition of faster diagnostic equipment

In the U.S., we're in good company in looking to computer simulation to improve ED care or avoid ED overcrowding. DIVURGENT shares here examples of practical ED simulations in Finland and the United Kingdom as well as in the U.S.

Case Study 1: Anticipating the impact of internal systemic or external changes

Researchers at the Massachusetts Institute of Technology in Cambridge[i] used computer simulations to evaluate how availability of inpatient beds impacts the ED. This type of simulation might be relevant for hospitals planning to close inpatient units permanently or temporarily due to renovations, for example, or to discover ways to approach high census periods, during flu season for example. In some U.S. states, simulation results might also be part of a certificate of need application either for ED expansion, construction of a satellite center or request for new inpatient beds.

MIT researchers performed initial data collection (a process discussed in general terms later in this paper) at an urban hospital and then ran 300 simulations of different scenarios. Among the variables were patient and staffing data for various times of day and different days of the week.

Their studies provided interesting results. First, the simulation showed that when the inpatient unit is crowded, the ED is more likely to be crowded as well. That was to be expected. Second, however, it also showed that the ED is sometimes crowded when the inpatient unit is not. This information gives stakeholders direction for improving operations in the ED and increasing resource utilization in areas that are unrelated to inpatient bed availability.

Case Study 2: Improving an existing ED

The goal of a Finnish computer simulation[ii] was to provide direction to a hospital with 34,000 ED patients annually whose stated goal was to reduce wait times to less than two hours for 80 percent of its patients.

Using off-the-shelf software, the initial computer simulation of existing ED patterns identified back-ups caused by delays in ordering of x-rays and other tests. Consultants worked with staff to develop a team-triage system for testing. In a new computer simulation, a team comprised of a receptionist, nurse and physician initially evaluate the patient and determine which diagnostic tests he needs. Clinicians then leave the patient to provide basic information to a receptionist, who then gets the patient underway for testing.

Taking advantage of one of the greatest benefits of computer simulation, the Finnish researchers ran multiple simulations, using eight different scenarios for patient acuity. Of special note, these simulations incorporated staff input and experience and had no direct impact on actual ED workflow.

The results of the simulation: the triage-team approach predicts a 26 percent reduction in patient throughput. The simulations also accounted for human variables such as staff's increasing familiarity with a new system. By running the model with these variables, the simulation also predicts that staff would eventually be able to decrease wait times to less than 12-14 minutes, compared to the initial goal of under two hours.

Case Study 3: Responding to renovations and new construction

Healthcare planners at one California system looked to computer simulation to analyze and predict the impact of a major and important move: the merging of six different EDs, into a shared (though quadrupled) floor space. Simulations were important for obvious reasons, but also because the EDs had a combined total 160,000 patient visits annually, and each was already overcrowded.

Computer simulation allowed the hospital system "to experiment with many scenarios without impacting the existing quality of patient care, . . . to mitigate risks and . . . solve issues months before transition to the new facility."[iii]

The computer model revealed how ED-specific and system-wide changes could (or even would not) maximize resources. Plus, because it was performed well before the bricks and mortar stage, the consultant-hospital staff team was able to run simulations with varying floor plans.

The results of various computer simulations were:

- Discharging patients five hours earlier would reduce length of stay (LOS) by one-third.
- Adding 30 more inpatient beds would cut ED LOS in half. Related, inpatient units were 10 percent undersized.
- Reducing lab test turnaround would not impact LOS in a significant way.
- The number of ED beds planned could be reduced by one-third.
- The new ED could handle up to 65,000 patients yearly before LOS would be unacceptable.

Consultants and stakeholders evaluated these results to focus further simulations on bedside triage and registration, changes to the time of day inpatients were discharged, reducing inpatient LOS and increasing the inpatient occupancy rate.

What's the process? What are the deliverables?

Like any large project, preparing for a computer simulation of an ED first involves determining objectives and ways to measure success in meeting those objectives. The case studies discussed above provide examples of realistic outcomes. An experienced consultant can assist you with defining reasonable goals and actionable conclusions for your facility.

The next, and one of the most time-consuming steps in computer simulation is data collection. Relevant raw data includes detailed floor plans, staffing levels by job category, numbers and job classifications of ancillary departments in the ED, average patient visits, level of trauma or illness, etc. Data at this stage could also include the number of and volume for entry points for patients, number of ambulance companies using the facility and any other number of factors.

Data collection often includes "shadowing" of patients and of all levels of staff by experienced recorders. Recorders capture as much information as possible to provide an accurate depiction of what happens in the ED, why certain steps are taken, how long they take, and what factors external to the ED impact these events.

Initial deliverables include reports created from the raw data and relevant to pre-defined goals. Examples include reports on average patient throughput, average number of patients seen per physicians, averages for specific physicians, and busiest times of day or week. For computer simulations using three-dimensional software, decision-makers can get a birds-eye, dynamic and time-stamped view of staff-patient flow throughout the ED. This allows them to identify visually where and when bottlenecks occur throughout the day or during a defined period of time.

With a good data set, a facility can run predictive simulations to evaluate the impact of both internal and external changes in patient numbers, staffing, physical plant design, workflow, etc.

Conclusion: The role of vendors and consultants in creating actionable results

Though computer simulations offer opportunities to analyze ED function in ways not otherwise desirable or even possible (as with predictive modeling), obtaining actionable results takes forethought, planning and experience. Qualified vendors and consultants, working closely with administrative and clinical staff throughout the process, lead to the best outcomes.

As demonstrated with the following hospital simulation project, lack of communication and buy-in wastes time and money. An unfortunate computer simulation experiment in a hospital in England offers lessons to avoid.

Case Study 4: Unintended consequences

The goal of one U.K. computer simulation[iv] was to evaluate how changes in patient throughput might impact ED wait times. Researchers ran two simulations: 1. using existing processes, where all patients are registered and seen first by a doctor; and 2. using a predictive model to test a new triage system, whereby certain patients with minor illnesses receive care from a nurse first, and then by a doctor before discharge. The computer simulation concluded that the second option would reduce wait time and decrease costs (because of reallocation of time of the more highly paid physicians).

However, upon actual implementation of the new system in the ED, nursing staff adopted the new system, but physicians did not. This lack of adoption required a second live experiment, where again key personnel created unintended (and un-simulated) workflow patterns. Researchers concluded that lack of staff buy-in did indeed hinder both data collection and implementation of a workable new process.

Computer Simulation: "A tremendous opportunity"

Simulations can capture complex human interactions in a way not possible with other tools. However, as the U.K. researchers learned, the integral role of professionals experienced in healthcare, in computer modeling and in change management are not to be underestimated.

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Even with the unintended outcomes discussed above, the academic researchers in England called computer simulation "a tremendous opportunity" for evaluating emergency department processes. As illustrated by the case studies, computer simulations identify critical issues, point to opportunities and pitfalls, and provide direction to address problems. Compared to other approaches, simulations offer these benefits quickly, easily, safely and with minimal negative impact on staff or patients. Even with such an imposing event as the merging of six EDs in California, computer simulations provided decision-makers with new directions about issues they had never experienced and which was not something they could easily intuit due to the sheer magnitude of the process.

Who knows better than we in the healthcare industry that high tech can go only so far without the high touch of experience. With administrative research into options, vendors and consultants and placing value on the integration of your own staff's expertise and experience, you have the keys to avoiding extra expense and maximizing patient care.

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