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THE BENEFITS OF SIMULATION MODELING IN MEDICAL PLANNING AND MEDICAL DESIGN

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ABSTRACT

Architecture, medical planning and the actual physical implementation of the facilities where care is rendered is often a source of great trepidation on the part of those who actually render care. Mistakes in this arena are very expensive and can hamper operations for years to come. Simulation is a tool that, though rarely used, can be very valuable in helping generate correct architectural decisions.

1 A COMMON SITUATION

The leaders of the hospital in Pennsylvania had watched the trends for years. Outpatient care was up over 60 percent in a five-year period and inpatient demand continued to dwindle. There is of course, nothing uncommon about this situation. Even though patient demand had changed, the hospital itself was still very much a traditional set of building primarily designed for the efficient delivery of inpatient care. Outpatients were either treated with the general population, or were cared for in small, discreet areas that were very difficult to staff. It was clearly time to do something. On the surface, the charge seems fairly simple;

- Create a new unit within the hospital that could bring together as much of the outpatient activity as possible
- Create a situation that allows better utilization of staff than a number of small units

So, how is this type of thing generally accomplished? As a fellow medical professional, see if any of this sounds familiar:

- Committees were formed. Nursing and medical leaders from cath-lab, surgery, medical outpatient testing, endoscopy, emergency department, clinical decision groups and 23-hour admission care were brought together.
- An architect was hired who in turn hired one of the many healthcare consultants available in the area
- Meetings were held. A chairman was assigned. Time frames were established. It was determined that within one year the unit would be designed, patient care patterns would be defined, staffing needs would be determined, and the hospital would move forward.
- The board suggested (strongly) that existing space within the hospital should be converted as needed to build this unit. The architect provided drawings of the spaces in the hospital that could be combined and converted most easily.
- The healthcare consultant collected the basic data that is always used in medical planning. Years of activity were reduced to averages and a set of assumptions was made. The unit would be planned around 75 percent utilization, and a certain amount of growth would be planned for. Industry standard heuristic planning methods were used to determine the number of patient spaces that would be needed.
- Progress was painfully slow. With all the different agendas at hand, it was very difficult to establish a common goal. Data sets from all the different departments were for the most part examined, analyzed and used separately.
- Progress was very slow. The year timeframe passed. Finally, after about 20 months the unit was designed, and things seemed ready to move forward.

There was mixed relief, optimism and skepticism on the parts of the committee members. The overall feeling though, was one of frustration and uncertainty. Nurses and doctors, over years of practice, develop a very acute sense of "correctness" or "incorrectness" about decisions. They may not know precisely why a decision seems correct or not, but this "intuition", is one of the most valuable tools of the clinical practitioner. Finally, several members of the committee became aware that simulation had been used elsewhere in the system. It was decided that simulation would be a good tool to test the new unit before it was built.

Simulation allowed a number of things to happen that were completely new in this process:

- The heuristic (rule of thumb) planning methods could be discarded. Most of these methods were developed with the huge influx of funds available to health care during the Hill-Burton initiatives, and they clearly address a different patient grouping and set of care patterns than is seen today.
- The data sets could be compiled separately, and then placed in the model, such that they interacted in a realistic fashion, over time.
- Averaging, as a planning method, could be discarded. The whole range of patient activity could be evaluated. This also allowed the planning team to stop using arbitrary utilization rates.

Very rapidly, within 2 weeks, a model was built that answered many of the "mysteries", that had surrounded this project for its duration. Averaging based programming and planning methods had greatly over-estimated the need for surgical beds, and under-estimated the need for medical beds. Because of the limitations of the existing space that had to be used, there was not a simple fix of just "switching" the beds. More importantly, because of the greater overall acuity of the outpatient population group, the entire unit would be saturated from the day it opened and had virtually no chance of accommodating the long-term growth patterns that were anticipated. The unfortunate answer of the model was something like this:

Don't build this unit because it will not work as you have planned for it to work. It represents a 4 million-dollar outlay that will not solve your problems. This staff time, spent in reaching a decision that in the end proved to be unworkable, is in many ways the most valuable resource that any hospital has. In addition to helping in creating good planning solutions, simulation can save a tremendous amount of valuable staff time.

Of course, had simulation been used early on in the planning process, these answers could have been generated much, much earlier. A huge amount of staff time had been devoted to decisions that were proven, just in time, to be wrong.

This is just one, but a very good example, of how simulation can greatly speed the planning and design process in the medical arena, and how far better information can be obtained by using simulation over averaging based methods.

2 LEARNING TO RELAX AND LOVE CHAOS

Since architectural change represents usually painful amounts of rapid capital expenditure, hospitals and clinics build as seldom as possible. Traditional planning methods have relied heavily upon "rules" of planning. When care patterns changed less rapidly and overall acuity was lower, these rules may have had a legitimate place in planning. However, most clinical situations are extremely complex and very dynamic. These rules simply don not work anymore. What we are confronted with instead might be better defined as "chaotic states." Since the rules for a "modeled" planning world can be so dynamic, simulation is an excellent tool to use in a chaotic environment. Some of these chaotic states can be reduced to a simple idea:

2.1 Chaotic Condition One

Most, if not all hospital departments, and hospitals themselves are not cooperative creatures. They simply will not respond in a clean and predictable fashion. Planning has to take into account the fact that exact behavior prediction is not possible.

2.2 Chaotic Condition Two

No two hospitals or hospital departments will respond in the same way to any given change. This makes it almost impossible to use "best practice" planning methods from one institution to another. The raw fact is, just becomes something works well at hospital A does not mean it will yield a good result at hospital B.

2.3 Chaotic Condition Three

If you attempt physical re-design of any hospital area or department without looking at process re-design, it will almost always be necessary to re-design processes in the future. The revers corrolary is also true.

2.4 Chaotic Condition Four

My concern is always more important than yours!! Differing agendas in a planning process can slow things down tremendously, and can ultimately cost huge amounts of money. Often the response is "design by committee", that meets no department's needs in a complete fashion. Modeling can allow these diverse agendas to be quickly compared in an objective, clear fashion.

2.5 Chaotic Condition Five

Many changes, both in physical layout and process can actually decrease “staff reach.” This is a difficult concept to grasp. Think of your arm reaching out as far as it will stretch. Now pretend that your outstretched arm represents the amount of time a nurse, doctor or tech has to render care. As you pull you hand back toward you body, your reach is diminished. During a given shift time can be broken down in several ways:

- Periods of time when patients need a caregiver’s time and the caregiver is available. This does not decrease your reach.
- Periods of time when patients don’t need the caregiver’s time and the caregiver is available. This may represent a problem in scheduling but overall reach is not decreased.
- Periods of time when patients need care, and some factor impedes the caregiver from rendering care. Every minute this happens is unrecoverable and decreases staff reach.

Modeling is the best tool currently available for identifying these impediments.

2.6 Chaotic Condition Six

Re-engineering is always painful and will always yield some unexpected results. Small changes in the medical arena can reverberate in such a way that their overall impact is much larger than might be anticipated. Because modeling allows you see a much larger piece of the picture, these “reverberations” can be predicted with much greater accuracy.

2.7 Chaotic Condition Seven

One “Aaaagh” has the power to erase ALL previous pats on the back, “ataboys” or “atagirls. The people charged with assuring that architectural changes are successful are working in an unforgiving environment. Mistakes have the power to destroy careers.

Clearly, simulation is the only readily available planning tool that allows situations with this level of chaos and complexity to be analyzed in a very quick fashion. In the medical arena, perhaps more so than anywhere else, the connection between the physical environment and the processes that processes that must be supported is very intimate. This creates a very “sensitive” situation where small mistakes can have large negative consequences. Conversely, small positive steps can yield benefits far in excess of their initial magnitude.

3 ADDITIONAL EXAMPLES

3.1 Surgical Design

It is very difficult to design an optimally functional surgery department, for a number of reasons. These include:

- More than any other hospital area, surgeries have an extreme dependence upon scheduling and staffing patterns. Since these are often deeply complex, it is common practice to over-design these areas.
- In most small areas, adjacencies are not terribly critical, however, this is not the case with surgical design. Surgeries are not only very sensitive to placement of important areas, but are very vulnerable to mistakes in room placement.

Simulation was used to directly compare 2 surgical layout designs at a hospital in South Carolina. After the best aspects of each system were found, simulation was used to optimize a third, hybrid system.

Once again, it was found that many of the heuristic programming methods used yielded erroneous data. Simulation did not replace the need for good architectural planning, but once again it allowed a great many problems to be avoided.

This example will be further described during the presentation.

3.2 Logistical Planning

A large, private hospital system in Texas was studying the possibility of creating a central distribution point for all materiel within the hospital. This distribution center would cost in excess of $20 million.

Since this hospital was composed of numerous buildings, all connected by tunnels, it became clear that the success of the system would depend, in a large part, upon the size and capacity of the tunnels.

In this case, architecture could do an excellent job of determining the optimal design of the actual distribution center, but it could do nothing to determine if the tunnel system was adequate to support such a system.

A simulation model, quite complex in nature, was built. The results of the model revealed information that could not be found with any other tool, other than building the system.

This tunnel system had been built many years prior and was quite adequate for “ local support” but could not even come close to properly supporting a system wide distribution system of the size that was being planned.

Simulation allowed alternative plans to be studied in a rapid fashion. Essentially, the $20 million still had to be spent, but the end result worked well. This example will also be discussed further in the presentation.

AUTHOR BIOGRAPHY

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