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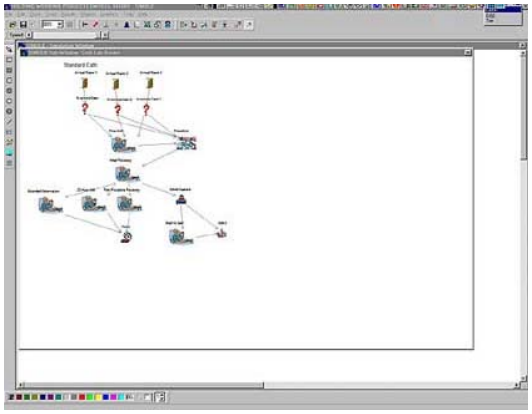
Holding, Hearts, and Hospital Simulations



Frank Zilm, DArch, FAIA
Frank Zilm & Associates, Inc.

Over the past 30 years, computer simulation of healthcare facilities has been demonstrated as a useful though daunting tool for evaluating programs and plans. Many packages offer sophisticated capabilities but also require extensive training and equally significant installation and maintenance budgets. Newer generations of software packages hold the promise for inexpensive, user-oriented tools. The planning of a major Heart Center for the Cleveland Clinic provided an opportunity to test low-cost simulation techniques in the analysis of holding beds for a combined heart surgery, cardiac catheterization, and electrophysiology lab service. Although effective, the software provided performance challenges. The search for a quick, cheap modeling technique appears to have hidden costs.

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Introduction

Over the past 30 years, computer simulation of healthcare facilities has been demonstrated as a useful, though daunting, tool for evaluating programs and plans. Many packages offer sophisticated capabilities but also require extensive training and equally significant installation and maintenance budgets. Newer generations of software packages hold the promise for inexpensive, user-oriented tools. The planning of a major heart center for the Cleveland Clinic provided an opportunity to test low-cost simulation techniques in the analysis of holding beds for a combined heart surgery, cardiac catheterization, and electrophysiology (EP) lab service. Although effective, the software provided performance challenges. The search for a quick, cheap modeling technique appears to have hidden costs.

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What is simulation?

Computer simulation modeling has evolved into a powerful tool for understanding operational issues in healthcare delivery and the relationship between operational performance and building design. As pressures to achieve efficiencies in operation continue, decisions will increasingly focus on understanding both dollar and life cycle costs associated with capital plans. Identification of the space necessary to meet the anticipated demand and to implement new organizational concepts to achieve staff efficiency presents questions that must be addressed in the planning.

A key characteristic of simulation modeling is the ability to incorporate the behavior of crucial system elements into a computer mock-up of the area under investigation. In an emergency room, for example, the arrival of patients into the ER, their diagnoses, use of diagnostic services, and length of stay in the facility vary significantly. To plan based on the average patient can lead to erroneous estimates of space requirements and staffing needs. Simulation models can take the statistical patterns for arrivals, length of stay, and other variables and incorporate them into the model of an existing or proposed service. This allows the decision makers to have detailed estimates of the performance of a service during peak periods of demand and other time periods. Room and staff utilization can be estimated along with information regarding waiting room capacity and queues that may develop for resources.

Because of the need to describe process flow, sample from statistical distributions, and monitor a system's performance, a specialized set of computer languages evolved in the 1960s and 1970s, including GPSS, SLAM, Simula, and Simon. Originally run in batch mode, these languages were the domain of the computer programmers, the geeks. The process was slow, and the output typically included reams of tabular printouts, requiring interpretation and explanation. Many users found simulations difficult to understand and either rejected the process or placed their trust in the programmer's recommendations.

Enter the PC. The revolution in interactive computer software and inexpensive hardware places simulation within the grasp of any architect, planner, and client. Batch applications have been replaced by interactive software, providing almost instantaneous responses to input. For the architects and client, one of the most significant improvements in simulation modeling is the development of graphic formats that allow the process and existing plans to be displayed.

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An example of a simulation package developed in the 1990s specifically for healthcare is MedModel by Procom Corporation. This package is very robust, allowing:
· Detailed descriptions of the flow of patients and other entities (instruments, x-ray images, etc.) through an area
· Decision criteria for the management of patients based on such characteristics as their disease type, the treatment spaces available for care, staffing patterns, and the physical flow through an area
· Capacity analysis of a system, measured in the percentage utilization of space and/or equipment, waiting queues for resources, and total time to provide care

One characteristics of the new generation of simulation modeling is animation, the ability to graphically show the flow of patients, staff, and equipment in a proposed space and in simulated time on the computer screen. This provides two significant advantages:
1.) A quick way to validate the model's performance and debug the models
2.) The ability to capture the clients attention and interest

The sophistication of a simulation language comes at a cost, including initial purchase price, annual technical support charges, and upgrades. Learning the language required an equal commitment of staff time for training and frequent modeling to maintain proficiency. These costs can initially exceed $20,000 with significant annual maintenance and upgrade charges.

Is there a middle ground? Perhaps. Along with these robust languages have emerged more generalized, cheaper, and easier to learn programs. A recent Internet check identified over 70 simulation programs and languages . One of these packages, Simul8, was used by the author in the planning of a major heart hospital for the Cleveland Clinic.

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Case Study - the Cleveland Clinic Heart Institute

One of the premier heart programs in the world, the Cleveland Clinic provides a broad range of treatment, research, and education programs in cardiac care. Over 5,000 heart surgeries; 11,000 cardiac catheterizations, PTCA, and vascular cases; and 4,000 EP procedures are currently performed each year.

To be the world leader in cardiac care requires excellence in clinical techniques and treatments, operational efficiency, the ability to adapt to constraints, and strong wills. Decision making is frequently based on the ability to recognize patterns and move quickly. Planning for change introduces the possibilities of new, unfamiliar operational and facility patterns. The ability to evaluate alternative paths can introduce uncertainties that may be perceived as threats to current success. How to fairly assess all options is a frequent problem in programming and planning.

The desire to improve the patient and family experience, combined with the expansion of surgery, cardiac catheterization, and EP services, generated new options for pre-procedure and post-procedure patient management:

- Combining all pre-procedure holding and preparation in one area, transporting patients to the respective diagnostic/treatment service
- Managing post-procedure outpatients and extended-care patients in this same area, swinging rooms between pre- and post-procedure functions
- Accommodating the anticipated shift in patients to 23-hour post-procedure care in this same area, freeing inpatient beds

These changes presented options that were difficult for the planning committee to visualize. Uncertainty regarding the total beds required, the resulting space and the operational requirements raised anxieties about changing the existing decentralized services.

This provided a classic opportunity for the use of simulation modeling. Could a model be built quickly to reflect the future workloads, patient mix and bed demand? Conceptually the modeling problem is straightforward, leading to the decision to utilize Simul8, a relatively inexpensive modeling package. Some of the anticipated advantages of this programming language was its graphic (Windows) orientation, the ability to build hierarchical models utilizing submodels, and the ability to integrate data and output with other software such as Microsoft Excel and Visio.

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Figure 1 illustrates a basic screen in the Simul8 system, a typical Windows format with toolbar pull-down items, graphic menu items listed on the left and the main work area in the center window. Each component of the proposed holding system is identified as an icon-cath lab rooms, angiographic rooms, biopsy rooms, etc. In addition to the care areas, two addition icons are show-a shift scheduler that opens and closes the door to the service, and a counter for total holding beds in use (Total Holding Beds).

One of the major characteristics of Simul8 is the ability to group related activities within a sub-window. In the Cleveland Clinic simulation, each icon was a symbol for a subgroup. By clicking on the icon with a mouse, the associated sub-activities appear, as in figure 2.

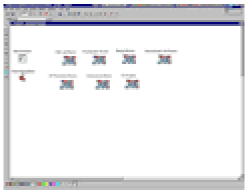

Figure 1

Each icon in this submodel represents an event or activity in the flow of patients through the cath lab. Since there are currently three standard cath Labs at the clinic, an entry door for patient arrival was set up for each room. This is not the most elegant and efficient way to model patient arrivals, but it was easiest for the users to understand. The possible flow of patients through the service is illustrated by the arrows, culminating in either the patient admission to an inpatient unit or discharge from one of three post-procedure holding modes (extended observation, 23-hour observation, or post-procedure recovery). A clear benefit of this simple, graphic orientation is that it helps the users understand and define the alternative paths and the associated probabilities of occurrence.

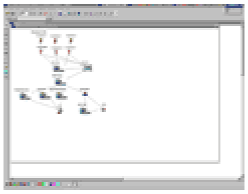

Figure 2

By clicking on an individual icon (referred to as a "Work Station" in Simul8) in this sub-model, the detail events, resource requirements and routing to the next event are defined. Figure x show a typical "Properties" box for the Preparation Holding areas. In this case, a 40- to 70-minute prep length of stay is defined, allowing the model to select individual patient lengths of stay randomly from a uniform distribution with these boundaries. The "Routing Out" selection allows the user to define where the patient will go next. For example, at the initial recovery location, patients can be routed to four different possible locations-extended recovery (4-8 hours), 23-hour observation, post-procedure recovery or inpatient admission. This basic model logic was used to build and adapt the patient flow for all room types. CV surgery has all patients transferred to an inpatient unit after surgery.

When patients are at a location that uses a holding bed they capture a resource titled "Total Beds." This is key to the model simulation; the simulation tracks the use of these beds throughout the simulation.

After the basic model logic was defined, the planning team established the existing and anticipated operational parameters.
(See figure 5).

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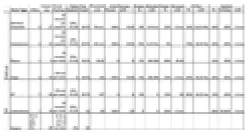


Figure 4

An essential component of any simulation modeling is the validation of performance, primarily based on output measures including total patients seen and length of stay in each area. There is typically an "ah-ha" phase at this point were the users realize that some key elements of the patient process were either misunderstood or incorrectly described.

Figure 3

Once model validation was achieved, alternative simulations were run altering specific variables:

· Projected patient volume
· Inclusion/exclusion of the cardiovascular surgery service
· Inclusion/exclusion of 23-observation
· Sensitivity testing of the length of stay assumption for post-procedure care

While the simulation is running, the utilization of the bed resource can be viewed. Figure 6 shows a simulation in progress with a window showing the beds in use over the time of the simulation. This result was then exported to an Excel spreadsheet for analysis.

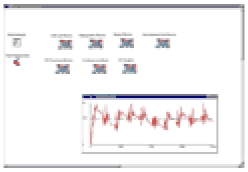


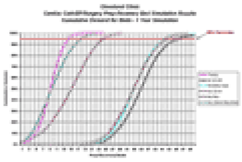
Figure 5

For each option simulated, a graph was prepared showing the cumulative probability of demand for beds. A goal of accommodating 95 percent of the total demand was established as the target for sizing the unit. Several issues became clear through the simulation:

·

The ability to accommodate 23-hour patients would produce too big of a unit to effectively manage
· The impact of the CV surgery program on the service was not significant
· Holding patients in a separate area outside of the procedure room has minimal impact on the bed needs

Use of the model resulted in the programming of a unit that consolidated the prep and post-procedure recovery for all services in one area and was slightly smaller than initially anticipated.·



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The Model Building Experience

During the development of these models, unusual performance of the simulation was experienced-unexpected crashes, non-intuitive results. You get what you pay for. It became clear that technical support was not immediate and that some of the features, such as hierarchical model structure, had problems. The stress level associated with debugging in a new modeling language that was acting unstable is an experience that is neither rewarding nor one that should be repeated. Although technical support was committed to correcting system problems, help frequently was not immediate.

Overall the experience was very positive in focusing the user groups thinking and clarifying future process patterns. The results helped resolve the issues of beds needed and the impact of consolidation.

The ability of Simul8 to accommodate a more complex system is unclear. Output results were difficult to interpret or appeared, in some cases, to be inappropriate for the task. Overall, the potential of low cost simulation packages looks promising. Simul8 and Extend appear to be two similar and promising contenders. The major constraint to use of these tools will be the availability of detailed data to drive the model and the learning curve to understanding the modeling methods and techniques. Stay tuned.

Appendix

Web sites for selected simulation packages:
Sumul8 http://www.simul8.com/
Extend http://www.imaginethatinc.com/
GPSS/H http://www.meridian-marketing.com/GPSS_H/index.html
Stella/iThink http://www.hps-inc.com/
SimProcess http://www.caciasl.com/simprocess.cfm
MedModel http://www.promodel.com/products/medmodel/

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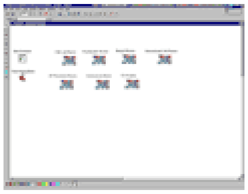

Figure 1

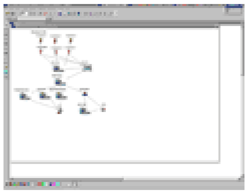

Figure 2

Figure 3

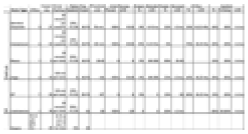

Figure 4

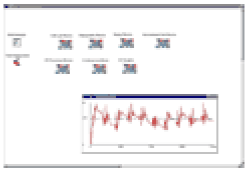

Figure 5

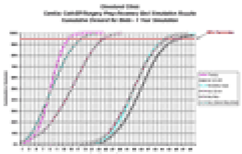

Figure 6

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Abstract

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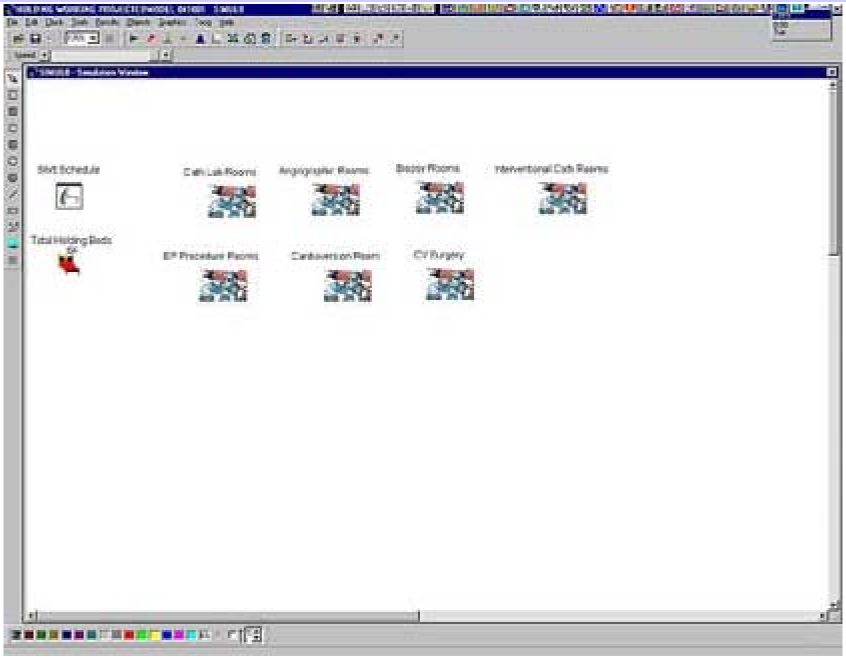

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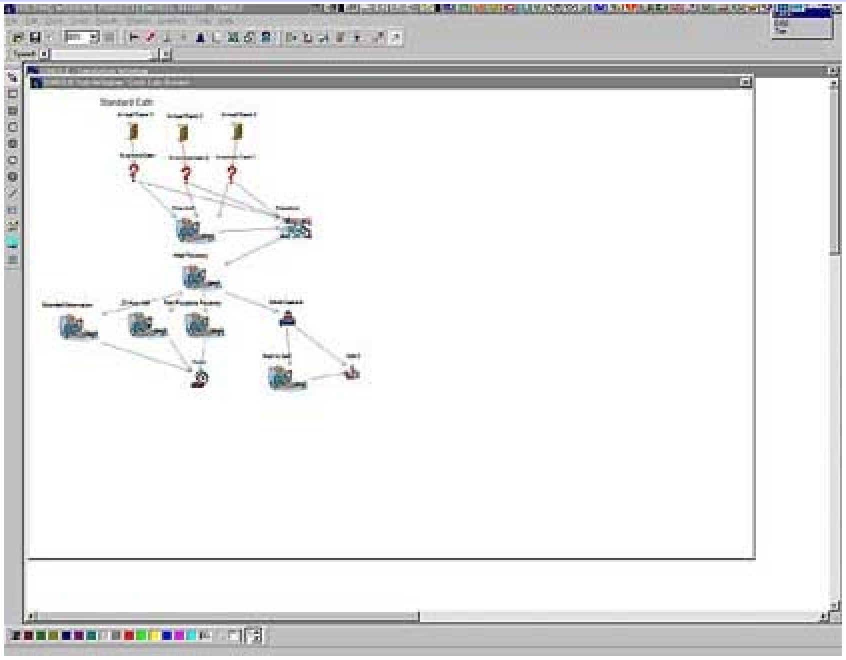

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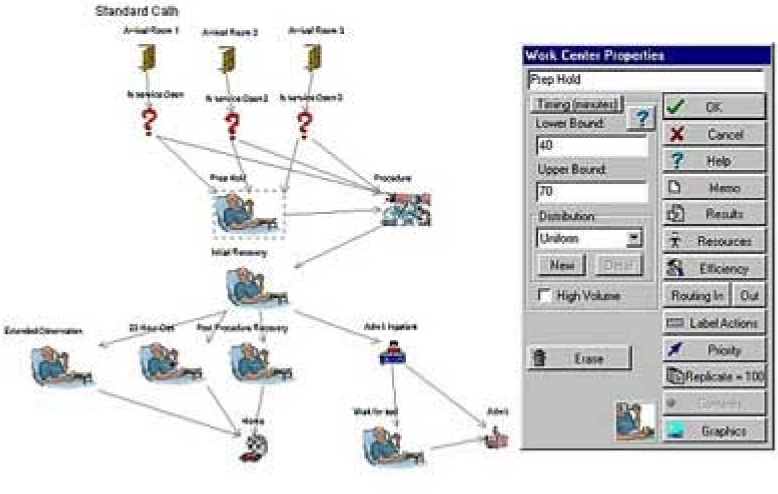

Work Center Properties

Prep Hold

Timing (minutes)

Lower Bound: 40

Upper Bound: 70

Distribution: Uniform

☐ High Volume

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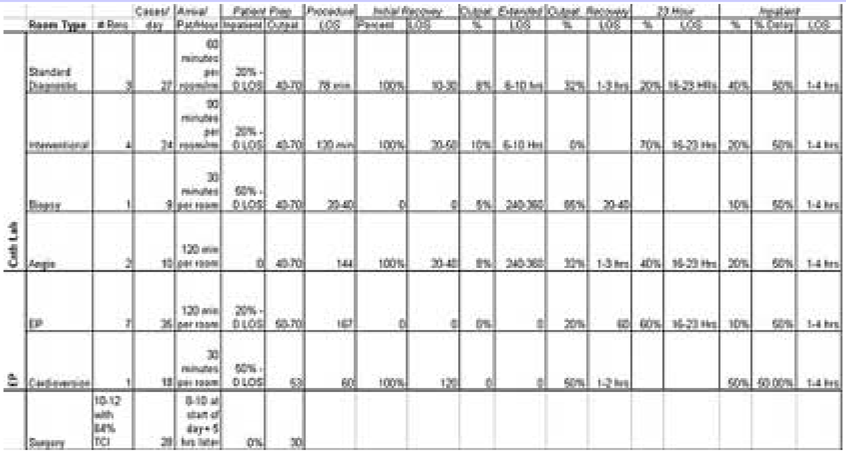

			Cases/	Arrival	Patient Prep		Procedure	Initial Recovery		Outpat	Extended	Outpat	Recovery	23 Hour		Inpatient		
	Room Type	# Rms	day	Pat/Hour	Inpatient	Outpat	LOS	Percent	LOS	%	LOS	%	LOS	%	LOS	%	% Delay	LOS
Cath Lab	Standard Diagnostic	3	27	60 minutes per room/hr	20% - 0 LOS	40-70	78 min	100%	10-30	8%	6-10 hrs	32%	1-3 hrs	20%	16-23 HRs	40%	50%	1-4 hrs
	Interventional	4	24	90 minutes per room/hr	20% - 0 LOS	40-70	120 min	100%	20-50	10%	6-10 Hrs	0%		70%	16-23 Hrs	20%	50%	1-4 hrs
	Biopsy	1	9	30 minutes per room	50% - 0 LOS	40-70	20-40	0	0	5%	240-360	65%	20-40			10%	50%	1-4 hrs
	Angio	2	10	120 min per room	0	40-70	144	100%	20-40	8%	240-360	32%	1-3 hrs	40%	16-23 Hrs	20%	50%	1-4 hrs
EP	EP	7	35	120 min per room	20% - 0 LOS	60-70	167	0	0	0%	0	20%	60	60%	16-23 Hrs	10%	50%	1-4 hrs
	Cardioversion	1	18	30 minutes per room	50% - 0 LOS	53	60	100%	120	0	0	50%	1-2 hrs			50%	50.00%	1-4 hrs
	Surgery	10-12 with 84% TCI	28	8-10 at start of day + 5 hrs later	0%	30												

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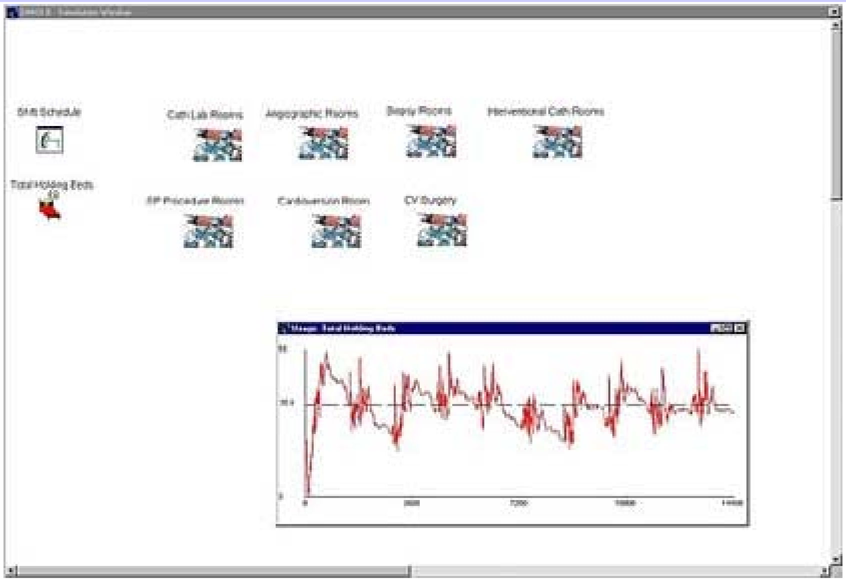

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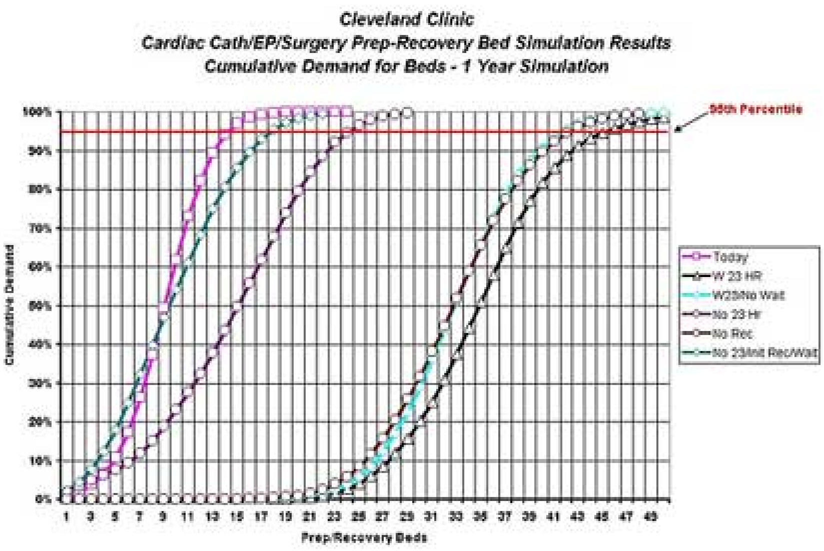

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This article originally appeared in The Academy Journal, published by the AIA Academy of Architecture for Healthcare (Volume 4, Part 1 – October 2001).