Analysis of Departmental Area in Contemporary Hospitals:

Calculation Methodologies & Design Factors in Major Patient Care Departments

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Abstract

This study documents and compares the relationship between departmental net and departmental gross square footages in five primary patient care, diagnostic, and treatment departments within contemporary hospitals, including Emergency, Radiology, Surgery, Acute Care Inpatient Units, and Intensive Care Units. The study examined 91 departments representing a cross section of work from at least eight architecture firms and 23 hospitals located in fourteen States plus the District of Columbia. It sought to identify both a range and mean of departmental net to gross area ratios in contemporary hospital design in the United States, in order to compare them to prior ratios, and to discover whether these ratios have undergone significant change in the context of the substantive changes occurring in healthcare practices and technologies.

The study began with a review of literature and industry standards for conducting net and gross area take-offs. The researchers used this information along with their collective practice experience to establish standardized protocols for conducting net and departmental gross area calculations used in the study. Autocad computerized drawing files of departmental floor plans were collected via a request for documents sent to health systems and nationally recognized architecture firms involved in the design of hospitals. Autocad layers were then prepared from plans received for both departmental gross and net areas. Space types [patient care, support, etc] were also designated for future study. The data from these files was automatically tabulated in the software and exported to comparative tables for each department type, eliminating the need for manual calculation and transfer of data. The data was then analyzed by the research team.

The original proposal expected to examine at least 20 departmental plans for each of the five departments; however some difficulty in acquiring plans from both firms and health systems limited the ultimate number [n] of plans studied for each department from 17 to 19 departments or units. Significant ranges in departmental net to gross ratios – from 0.33 to 0.62 - were found in the study group while the mean net to gross ratio for each departmental category fell within a range of 1.53 to 1.61. The limited size of the study group, and the range in total square footage for the departmental areas available to the team, serve as significant qualifications to the results of the study. While this study is a valuable start, both a larger sample [n] and set of departments need to be examined before more definitive conclusions can be reached. Calculating departmental net and gross areas in contemporary facility design involving a range of “open” areas also calls for a significant number of judgment calls, as the net area of spaces not defined by four walls can easily be interpreted multiple ways. This study indicates the need for better defined and shared industry standards in calculating departmental net and gross areas.

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Academy of Architecture for Health Foundation, American College of Healthcare Architects, Anshen+Allen, Cannon, Chong & Partners, Frank Zilm & Associates, Inc, HKS, HLM, HOK, Leo Daly and Associates, McKahan Planning Group, Moon Mayoras Architects, Philo Wilke, The SLAM Collaborative, The Smith Group, and one unnamed health system.

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Introduction

In the Fall of 2005 the investigators received grants from Frank Zilm & Associates, the Academy of Architecture for Health Foundation, the McKahan Planning Group, and the American College of Healthcare Architects to conduct a study of recent departmental areas in contemporary hospital projects. The objective was simple: to determine whether net-to-gross ratios for the design of major hospital departments had changed significantly during the recent period of rapid change in the field. It was planned as a retrospective study of completed new hospital projects and focused on five of the most significant patient care and treatment departments commonly found in all hospitals: Emergency, Surgery, Imaging, Acute Inpatient Units, and Intensive Care Units.

Importance of the Study

Ratios used to calculate proposed departmental gross square footage constitute key information used in the process of programming, planning and design. The ratio of net [usable] square footage to departmental gross square footage is commonly called the “net-to-gross ratio.” It is used by programmers, planners, and consultants to project the total area of proposed departments based on programmed net square feet required to perform the proposed workload of the department. This multiplying ratio, or grossing factor, is intended to estimate the amount of un-programmed space needed to effectively organize the net, or programmed, spaces within each department before the final design is known and the actual area for these elements can be determined.

Rapid changes in the field have left practitioners with potentially outdated and less reliable information about best practice benchmarks for space utilization in key departments of hospitals. As the inventory of healthcare facilities in the U.S. ages [many constructed with Hill-Burton funding some 40-50 years ago] and as the Baby Boom generation rapidly increases the population of aging users of healthcare resources, health facility construction is predicted to exceed $250 billion in the coming decade. To meet this challenge, healthcare architects, their clients, and programming consultants need information on the current status of space utilization based on contemporary planning needs in the newest projects by respected firms.

If the programmer of hospital space knows the function of a space or room that will be needed in a proposed project, they can calculate with considerable accuracy the net square footage required. For this reason, net square footage space requirements are usually fairly accurate. In order to increase the projection to account for thicknesses of walls, internal departmental corridors, space allocated to columns and structure, or mechanical and plumbing shafts, the programmer typically relies on ratios based on calculations of actual past projects. This net-to-gross ratio is a sophisticated guess that can only be confirmed by an actual design layout, but is crucial as it is frequently used to establish a budget. Different architects and programmers may be using somewhat different factors for these ratios, but generally speaking, industry practice had developed around ratios that had consensus around ranges of fairly tight variance. The research question is whether the actual net-to-gross ratios of key departments had changed in recent years as new clinical practices, regulatory standards, space needs, spatial configurations and technologies have been introduced.

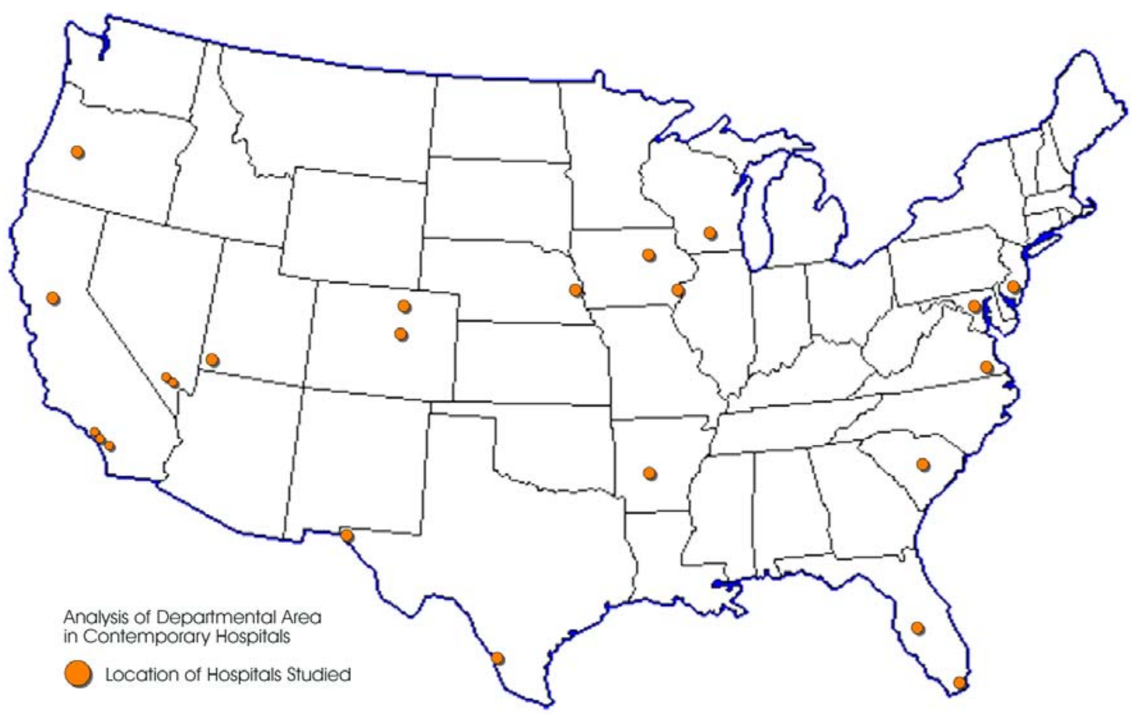
If these frequently used ratios have in fact changed in built projects, it is vitally important for practitioners to have this new information at the earliest possible moment in order to assure that the enormous coming investment in health facilities can be properly planned and budgeted. If they have not changed, practitioners and their clients can be reassured that the data and factors on which they have traditionally relied can continue to be useful.

While some healthcare planning and architecture firms periodically back check their own designs and monitor the actual versus predicted net to gross ratios, the principal investigators are unaware of any systematic study of actual net to gross ratios that have been executed across the work of many firms and health systems and made publicly available to the industry.

Projects Included in the Study

The objective was to examine the widest possible cross section of hospitals in the United States. Projects were solicited from firms and healthcare organizations. Twenty three facilities in fourteen states plus the District of Columbia were analyzed, including projects from Arkansas, California, Colorado, Florida, Iowa, Nebraska, Nevada, New Jersey, Oregon, South Carolina, Texas, Utah, Virginia, Wisconsin and Washington DC. The work of at least eight different architecture firms was included in the final data set: Anshen+Allen, Cannon, Chong & Partners, HKS, HLM, Leo Daly and Associates, Philo Wilke, and The Smith Group. Projects submitted by a participating healthcare organization were blinded, so the architects and name of the projects remain unknown. Three submitted projects were not included due to misplaced, incomplete or corrupted files, or they turned out not to be hospital based departments.

Figure 1: U.S. Map showing location of hospitals studied



Methodology

The research methodology consisted of multiple phases: data collection, the development of take-off protocols and the actual takeoff and tabulation of the submitted projects, the interpretation of the data, and the development of conclusions.

Data Collection

Requests for project examples were sent to major firms identified as among the top 25 in the five previous annual *Modern Healthcare* rankings of healthcare design firms. The study began in January of 2005. Documents were sought and collected through mid-summer 2006. Area take-offs were completed at Clemson University and data gathered through the summer of 2007.

Literature Review

A literature review was conducted at Texas A&M University while the project information was being solicited and collected. This review revealed that there is relatively little in the literature about calculation of area, and even less about the specific issue of net and gross area calculation for hospitals and healthcare projects. [Refer to the appendices for a comprehensive listing of resources examined for this study] The most frequent and consistently referenced source for healthcare architecture is the decade-old document produced by the American Institute of Architects, AIA D101-95 (AIA. <u>The Architect's Handbook of Professional Practice</u>. 2001 ed.: John Wiley and Sons). There is no guidance in this document on calculating departmental gross square feet in healthcare facilities. As a result, at best, individual firms set their own guidelines for taking off net and gross areas. At worst there may even be variation within firms depending on the individuals conducting the takeoffs. The obvious conclusion of the literature review is that there is a need for a healthcare specific methodology for departmental and building area calculation that is common to architects, programmers, consultants, and contractors.

Area Take-off Protocols

In order to conduct the study the research team had to first define protocols for conducting the area takeoffs, given the lack of published and industry accepted standards for determining net [NSF] and particularly departmental gross square feet [DGSF]. It is relatively easy to achieve consensus and consistent calculations on net square feet of an enclosed room. However establishing standards for calculating net square feet in open areas, and determining departmental gross square feet in a very diverse range of conditions is much more complicated. It was impossible to anticipate all possible conditions and variations found even in this limited number of projects, so a series of judgment calls or interpretations had to be made by the principal investigators during the process of conducting take-offs. The following represent both the significant standard definitions and protocols for conducting the area takeoff in this study and some of the most common judgment calls.

NET SQUARE FEET (NSF): This is measured as the space within the walls of a room, or the usable floor area assigned to a function in an open area e.g., cubicles, staff work areas or workstations. This space includes the floor area needed for casework, furniture, fixtures and door swings but does not include wall thicknesses. It is measured from the inside face of all walls and enclosing elements. It does not include structural elements such as columns and column enclosures that may protrude into a room.

Net square feet in open areas were measured as mentioned above whenever possible (Figure 2). The net square feet of nurse stations, staff work areas, work alcoves, and equipment alcoves open to corridor[s] were recorded to the corridor face of millwork, face of adjoining corridor walls or edge of required means of egress or exit corridors (Figure 3). The net square feet of treatment and patient care areas open to the corridor were calculated to the cubicle curtain enclosure when evident on the plans.

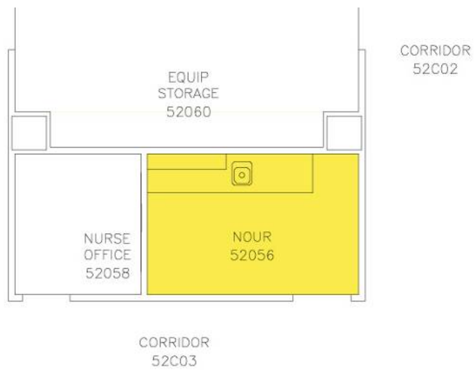


Fig 2: NSF: Enclosed Room

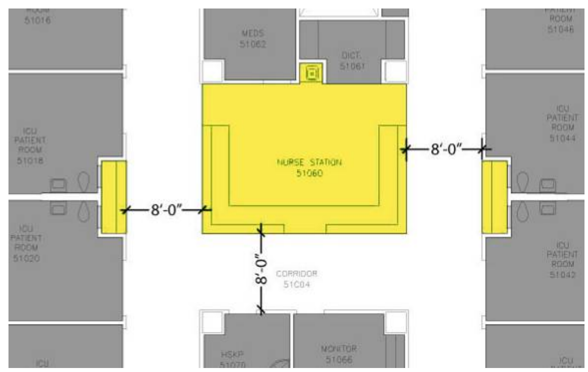


Fig 3: NSF: Open Area at Nurse Station

DEPARTMENTAL GROSS SQUARE FEET (DGSF): This is calculated as the total net and gross areas generally demarcated by the interior face of exterior walls enclosing departmental areas, the centerline of interior walls separating spaces in one department from those in another, and the centerline of corridors separating and serving as access to spaces in two adjoining departments. Departmental gross area was calculated to include interior walls and internal departmental circulation areas. Interior structural and system elements such as columns, brace frames, thickened walls and localized plumbing chases were also calculated as part of the departmental gross area, as these elements would not always be set, sized, distinguished or measurable during the initial planning of the department (Figure 4).

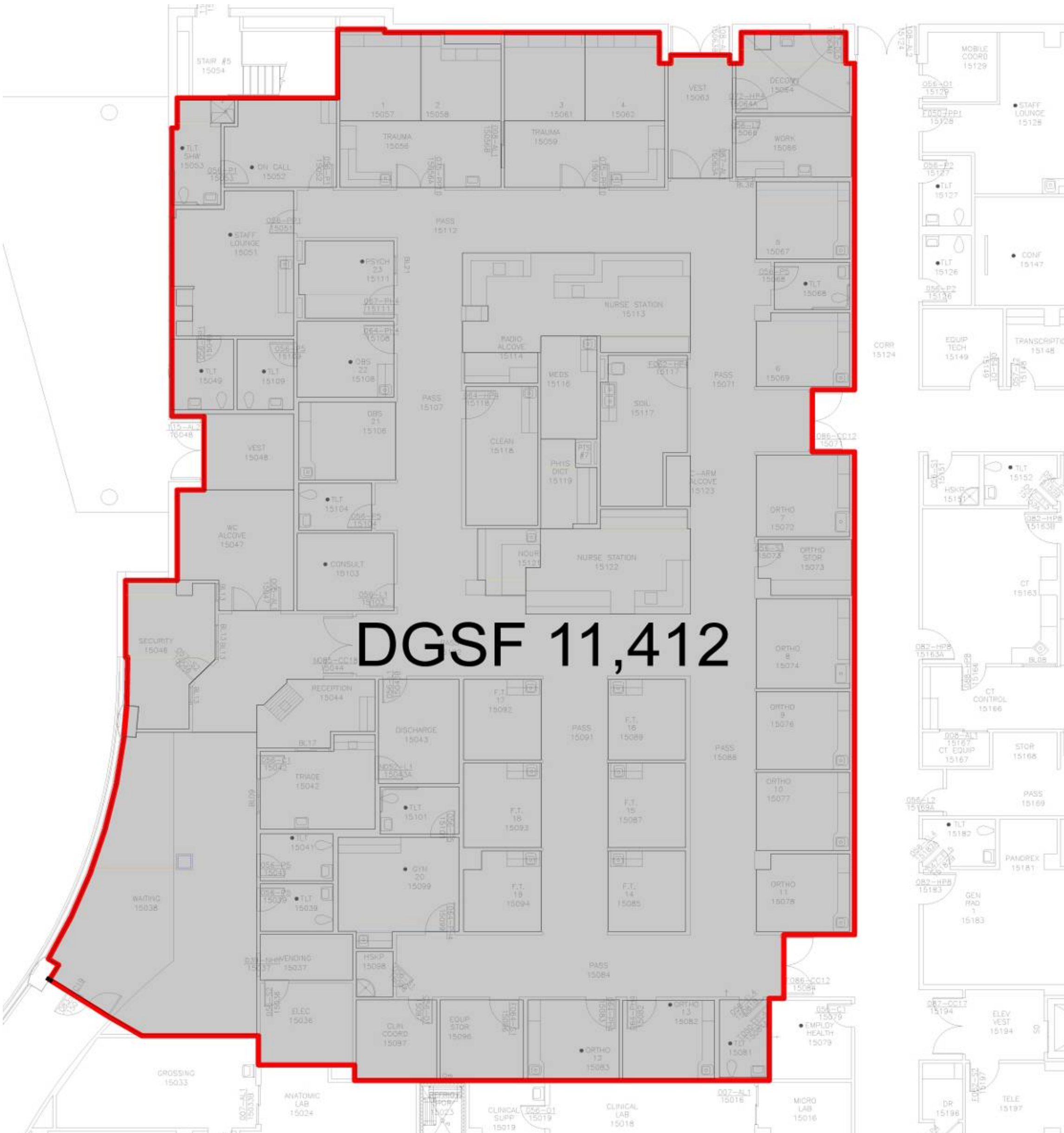


Fig 4: Departmental Gross Square Feet (DGSF)

COMMON EXCEPTIONS IN CALCULATING DGSF: Certain elements were excluded from the calculation of departmental gross areas. Corridors used primarily as interdepartmental circulation passing through or along the edge of a department were not included. The corridors in these situations were assumed to be part of the "building gross" or "floor gross" area. Likewise, corridors running between departments, and providing access primarily to individual spaces within one department, were assigned to that department and not split between both. An example would be where the corridor provides the only access to multiple patient care or support spaces in one department and does not provide access to similar spaces in the other department, but may also provides inter-departmental circulation to the other department. The plan below [figure 5] indicates an example of this condition. In these cases, the corridor face of corridor walls was set as a departmental boundary.

Another common exception included fire and building wide stairways, elevator shafts and similar building wide elements that fell within or along the edge of departments were also excluded from the departmental gross area. In these cases, the departmental face of walls enclosing these elements was defined as the departmental boundary (Figure 5).

Fig 5: DGSF Exceptions - corridor, shafts and stairways not assigned to a department

Given the range of departmental configurations in the hospitals studied, there were still areas that required case by case judgment calls to be made in determining both net and departmental areas. In some cases, departmental areas were extruded and somewhat contorted in configuration calling for interpretation as to the extent of departmental and interdepartmental circulation. It was also often important to look beyond the departmental boundary to determine whether corridors passing through or along departmental boundaries were departmental circulation or primarily interdepartmental circulation and therefore not included in departmental gross area calculations. This requires that entire floor plans be examined rather than simply departmental plans. In some cases the team did not have access to complete floors plans.

Other common judgment calls involved the determination of net or departmental gross area resulting from the increasing amount and range of open staff areas, and other areas open to the corridor found in contemporary hospitals. Circulation pathways serving multiple purposes, but sized or required by code for egress, or needed for functional access to enclosed rooms, were typically counted as circulation instead of net space. In these cases only functional space outside of circulation was consider net. [see figure 3 for example at nursing substations]. Large blocks of unplanned shelled space, more typical in Imaging, were excluded as it was difficult to identify or distinguish necessary departmental gross space required to access and utilize unidentified program spaces. A table of judgment calls made in this study can be found in the appendices.

The authors found that in certain cases even the same person might make a different ruling on the same condition at different points in times, let alone the difference in interpretations possible when different individuals come across the same condition. It is important to recognize that there will always be judgment calls in determining net and gross areas; however this study involved a deliberate attempt to minimize these situations, reach consensus when interpretation was required, and define rules and exceptions for as many conditions as possible.

THE NET TO GROSS RATIO: This ratio is determined by taking the entire Departmental Gross Area as defined above and dividing it by the sum of all Net Departmental [program] Areas. This number is typically rounded to two decimal points.

$$\frac{\text{Departmental Gross Area [DGSF]}}{\text{Total of Net Areas}} = \text{Net to Gross Ratio}$$

Area Takeoff Tools and Methodologies:

Once takeoff protocols were defined, departmental net and gross calculations were performed by graduate students from Clemson University and Texas A&M working with electronic drawing files provided by the firms responsible for the projects. The students worked under the supervision of the principal investigators (Allison and Hamilton) and interacted electronically via e-mail, telephone, videoconference and a file sharing web site set up at Clemson University to coordinate their work.

Construction drawing floor plans from recently completed new hospital construction projects were received and analyzed. It should be noted that not every hospital was able to contribute all five departments to the study for various reasons. The methodology to calculate the net to gross ratio for each department employed Autodesk Architectural Desktop (ADT) software. The particular method allowed the seamless extraction of data from the individual floor plans into spreadsheet form in Microsoft Excel (Figure 6).

The method eliminates any error from manual transfer of square footages from the floor plans into Microsoft Excel to generate the net to gross ratio. It also allows the expression of department spaces and boundaries graphically. A color key was created and different functional areas were assigned different colors to distinguish “space typologies” within each department. For example patient care areas, support spaces, and administrative spaces were all tagged with a different color. This allowed for ease in reviewing the drawings and making any necessary corrections.

In addition to a color coding system, a naming convention was developed for each space type within the department. For example, an inpatient room area in a medical/surgical unit is labeled “04-430-PC” Patient Room in the ADT drawing. The “04-430-PC” identifies the area by floor in the hospital (04), room number on the drawing (430), space type (PC for patient care) and a light blue corresponding space type color. The area tool in ADT was used to generate the square footage for each departmental net area and the overall departmental gross area. The area utilized is “stretched” over the corresponding space on the drawing by activating the area or “editing its vertices” (Figure 7).

Centennial Hill Hospital		
Shape ID	Department/Function	Calculated Area
00-0000	Base with Mech Shafts/columns	21530 SF
00-0000	DGSF	21263 SF
01-11000-PC	Exam Room-Semi	316 SF
01-11001-PC	Storage	47 SF
01-11002-PC	Decontamination	149 SF
01-11002-SP	Scrub Alcove	4 SF
01-11002-SP	Scrub Alcove	4 SF
01-11003-SP	Staff Vestibule	235 SF
01-11003-SP	Scrub Alcove	4 SF
01-11003-SP	Scrub Alcove	4 SF
01-11003-SP	Scrub Alcove	4 SF
01-11004-SP	Emergency Medical Technician	116 SF
01-11006-PC	Exam Room-Semi	334 SF
01-11008-SP	Physician Dictation	26 SF
01-11009-SP	Scrub Alcove	4 SF
01-11009-SP	EMS Equipment Alcove	17 SF
01-11010-NS	Nurse Station	473 SF
01-11012-PC	Isolation Room_Toilet	58 SF
01-11014-PC	Isolation Room	173 SF
01-11015-PC	Exam Room	105 SF
01-11016-PC	Exam Room	101 SF
01-11017-PC	Exam Room	101 SF
01-11018-PC	Exam Room	101 SF
01-11019-PC	Exam Room	101 SF
01-11020-PC	Exam Room	93 SF
01-11020-PC	Exam Room	137 SF
01-11022-PC	Exam Room	90 SF
01-11023-PC	Exam Room	90 SF
01-11024-SP	Staff Lounge	170 SF
01-11024-SP	Equipment Alcove	28 SF
01-11025-SP	Staff Toilet	56 SF
01-11028-SP	Nourishment	106 SF
01-11029-SP	Equipment Alcove	50 SF
01-11030-AD	Office	80 SF
01-11032-PC	Patient Toilet	49 SF
01-11036-SP	Clean Supply	110 SF
01-11038-SP	Meds Supply/Storage	105 SF
01-11040-SP	Soiled Utility	109 SF
01-11050-PC	Cardiac Exam Room	255 SF
01-11052-SP	Storage	157 SF
01-11054-PC	Cardiac Exam Room	252 SF
01-11056-PC	Exam Room	101 SF
01-11058-PC	Exam Room	101 SF
01-11060-PC	Exam Room	101 SF
01-11062-PC	Exam Room	101 SF
01-11064-PC	Exam Room	101 SF
01-11066-PC	Exam Room	101 SF
01-11067-SP	Housekeeping	36 SF
01-11069-SP	Blood Gas	62 SF
01-11127-SP	Decontamination Storage	71 SF
01-14001-SP	Scrub Alcove	4 SF
01-14001-SP	Scrub Alcove	4 SF
01-14001-SP	Scrub Alcove	4 SF
01-14001-SP	Scrub Alcove	4 SF
01-14027-SP	Storage	83 SF
01-14028-SP	Security	193 SF
01-14030-PB	Vending	182 SF
01-14031-SP	Housekeeping	51 SF
01-14032-PB	Toilet	132 SF
01-14034-PB	Toilet	127 SF
01-14038-AD	Admitting	506 SF
01-14040-PB	Waiting	3074 SF
01-14042-PB	Waiting	241 SF
01-14044-PC	Triage Room	115 SF
01-14046-PC	Triage Room	115 SF
01-14048-SP	Consultation Room	115 SF
01-14049-SP	Storage	211 SF
01-14050-NS	Nurse Station	266 SF
01-14052-AD	Office	125 SF
01-14054-SP	Clean Supply	117 SF
01-14056-SP	Soiled Utility	126 SF
01-14060-SP	Nourishment	105 SF

Figure 6: Color Key and Export Table in Architectural Desktop

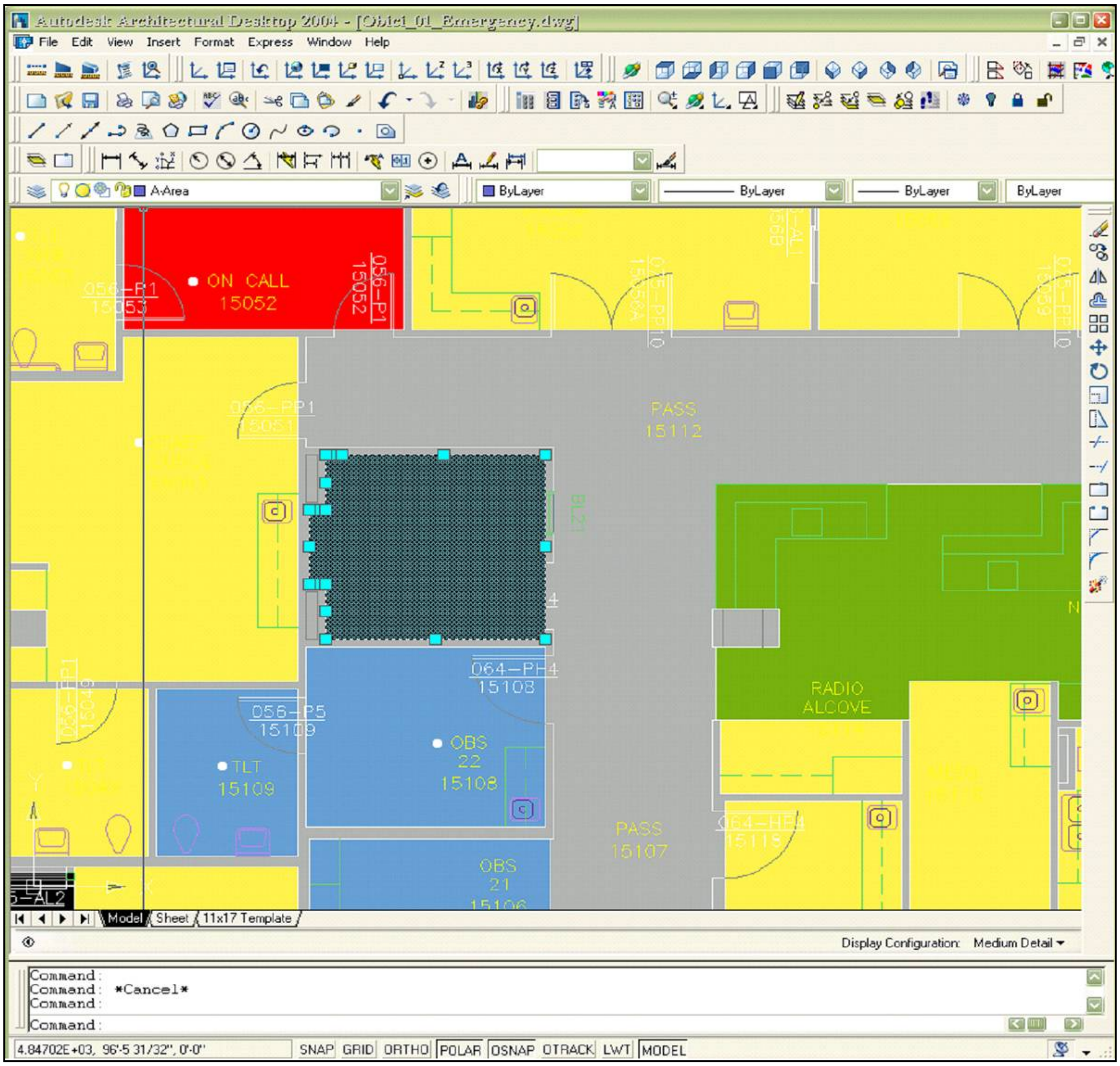
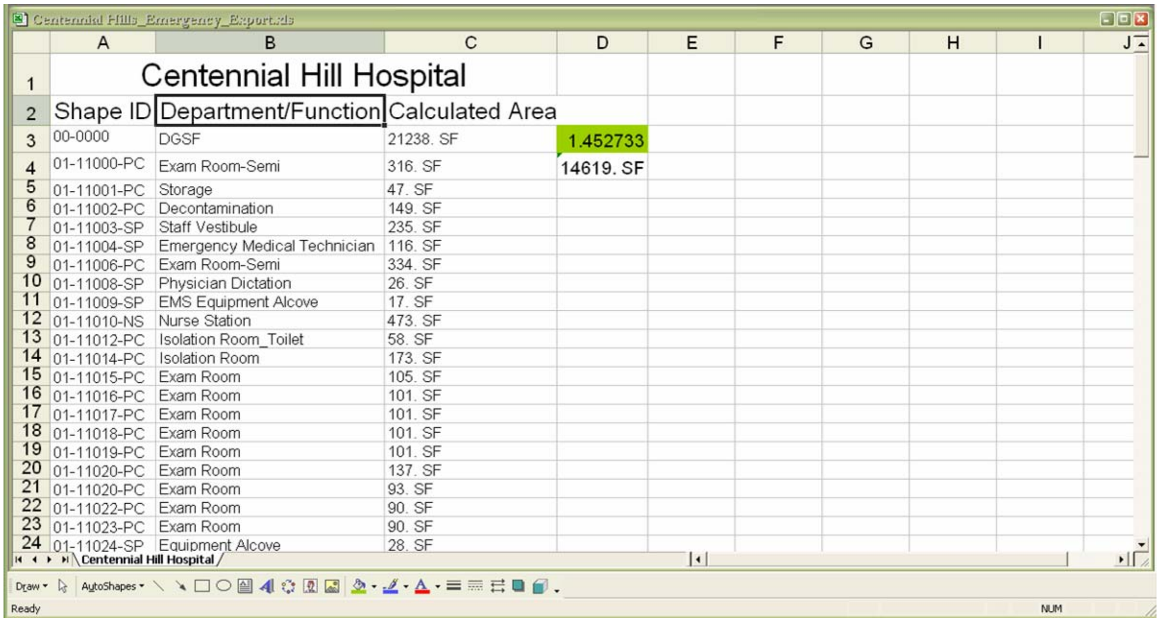


Figure 7: Floor plan showing an "activated" area

This enables the user to click on the space boundaries and stretch the area around the space. These areas, as the name implies, generate square footages for the individual space that it defines and were given an identification number and name corresponding to the department space on the floor plan. This data (number, name and square footage) was then tabulated utilizing a schedule table in Autocad Architectural Desktop. The schedule table reads the name, number and square footage from each area and creates a table summary of the data from all areas on the drawing. (Figure 6) The table is then exported directly to Microsoft Excel to generate the net to gross ratio from the extracted areas. (Figure 8)

The research team then created a master Microsoft Excel sheet to consolidate the Excel exports from each individual drawing. This master workbook allowed the generation of an overall net to gross average for each department and the organization of data for use in future studies.



	Shape ID	Department/Function	Calculated Area	
1		Centennial Hill Hospital		
2	Shape ID	Department/Function	Calculated Area	
3	00-0000	DGSF	21238. SF	1.452733
4	01-11000-PC	Exam Room-Semi	316. SF	14619. SF
5	01-11001-PC	Storage	47. SF	
6	01-11002-PC	Decontamination	149. SF	
7	01-11003-SP	Staff Vestibule	235. SF	
8	01-11004-SP	Emergency Medical Technician	116. SF	
9	01-11006-PC	Exam Room-Semi	334. SF	
10	01-11008-SP	Physician Dictation	26. SF	
11	01-11009-SP	EMS Equipment Alcove	17. SF	
12	01-11010-NS	Nurse Station	473. SF	
13	01-11012-PC	Isolation Room_Toilet	58. SF	
14	01-11014-PC	Isolation Room	173. SF	
15	01-11015-PC	Exam Room	105. SF	
16	01-11016-PC	Exam Room	101. SF	
17	01-11017-PC	Exam Room	101. SF	
18	01-11018-PC	Exam Room	101. SF	
19	01-11019-PC	Exam Room	101. SF	
20	01-11020-PC	Exam Room	137. SF	
21	01-11020-PC	Exam Room	93. SF	
22	01-11022-PC	Exam Room	90. SF	
23	01-11023-PC	Exam Room	90. SF	
24	01-11024-SP	Equipment Alcove	28. SF	

Figure 8: Table in Excel

FUTURE POTENTIAL OF TAKEOFF METHODOLOGY: The digital methods used for area take-off, tagging and transfer of data will allow the research team to easily use take-off data in the future to generate a percentage of space type per department based on the total square footage of each type within the particular department (Fig. 9). This will permit further research on the same data for a better understanding for the proportion of space types within each department type. For example, the emergency department summary illustrates the ratio of patient care space to departmental circulation is approximately 1:1.3. Also, the amount of support space relative to patient care space is close to a ratio of 2:3.

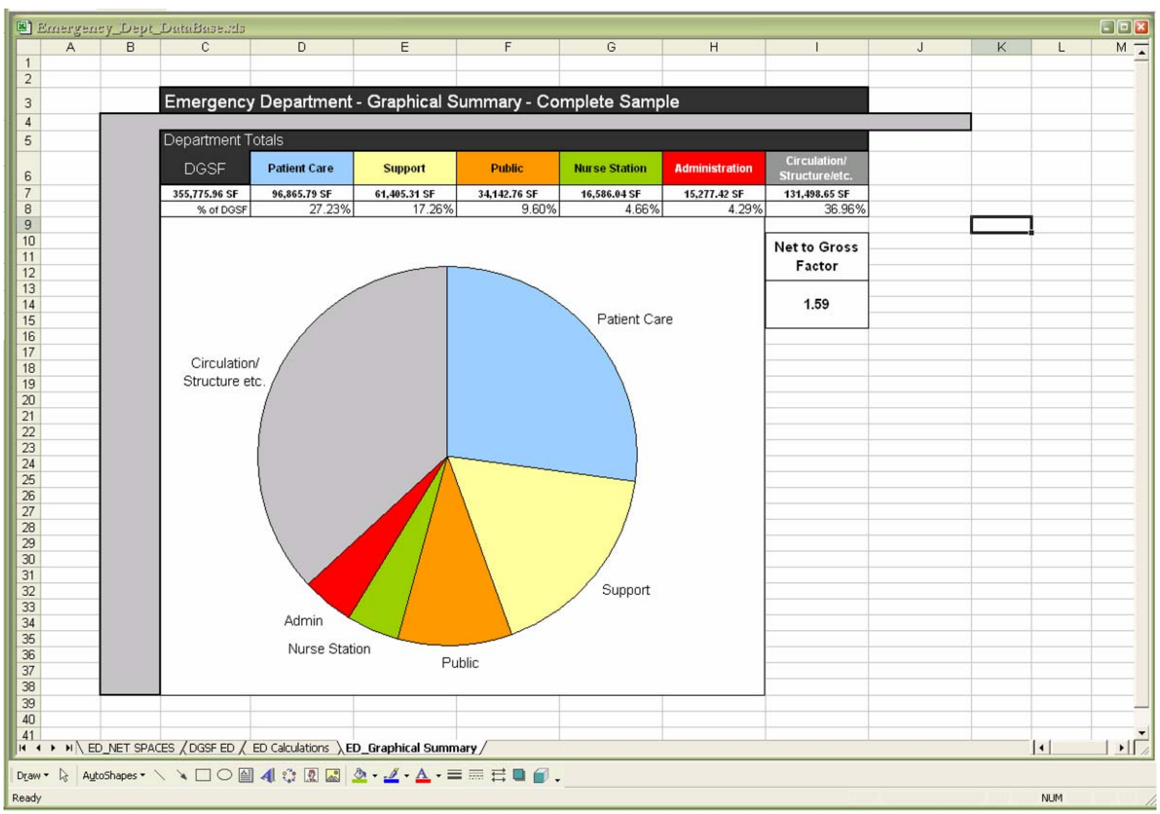


Figure 9: Comprehensive Graphical Summary Chart

Overall Findings

Analysis of Departmental Area in Contemporary Hospitals						
DEPT	n	MIN	MAX	Range	MEAN	STANDARD DEVIATION
EMERGENCY	18	1.39	1.77	0.38	1.58	0.11
IMAGING	17	1.34	1.67	0.33	1.53	0.09
SURGERY	19	1.46	1.80	0.34	1.61	0.10
INPATIENT	18	1.39	1.79	0.40	1.56	0.10
INTENSIVE CARE	19	1.34	1.96	0.62	1.56	0.15
Departments Studied	91					

Fig 10: Comprehensive Department Results Chart

While the mean net to gross ratio for each department or unit type fell close to predictable factors, the range in departmental grossing factors within the sample was higher than might be expected. This seems to be result of departmental/unit configuration, departmental/unit size, and the variation in amount of infrastructure elements within some departments.

The highest net to gross factors were not surprising, given the conditions they represent. The imaging and surgery departments at Providence St. Joseph's Medical Center had the two highest net to gross ratios in their respective categories. In both cases these departments were contorted plans in irregular shapes with elongated extensions creating an extended circulation pattern. Both of these departments had extensive perimeter single loaded corridors around treatment cores. Providence Hospital Northeast had the ICU and Acute Care units with the highest net to gross ratios. Both shared the same elliptical plan configuration. The acute care inpatient unit had a very large and undefined common area at its center, and the ICU was the only unit studied with a perimeter corridor providing separate access to patient rooms for family access. The ED with the highest net to gross ratio was at St. John's with no dramatically distinctive configuration or design features to suggest a reason for its ratio.

In some cases the net to gross ratio may have been calculated as higher because the formal entry to a department or unit could only be ascertained by locating cross corridor doors. In some cases this created corridor extensions to the department increasing circulation assigned to that department. Shelled space and other departments or services physically embedded within some of the sample departments also may have also contributed to higher net to gross ratios.

The low grossing factors within each departmental category, except surgery, were particularly surprising. It should be noted that George Washington Hospital had the lowest net to gross ratio in four of the five departments studied: Emergency, Imaging, ICU and Acute Inpatient Care. The lowest net to gross ratio in Surgery was found at UC Davis Medical Center which had a very large Surgical Department with 24 standard Operating Rooms organized in a very regimented and efficient configuration. It is not surprising that the low net to gross ratio for Surgery was higher than that of other departments due to a higher frequency of single loaded and perimeter corridors found in the sample.

Findings: Emergency Services

Eighteen emergency services departments were included in the initial sample, ranging in size from 7,944 to 40,850 departmental gross square feet. Most of the samples were community hospital facilities. There were at least two teaching hospitals that could be identified. It is not known if any of the facilities were classified as a Level 1 trauma service.

All of the designs, with the exception of two facilities, could be defined as "ballroom" layouts, with exam rooms wrapped around a single, or multiple, staff work stations. Two of the designs incorporated parallel corridors in a design sometimes described as "fingers."

Emergency: mean ratio of NSF to DGSF gross = 1.58 (n=18)

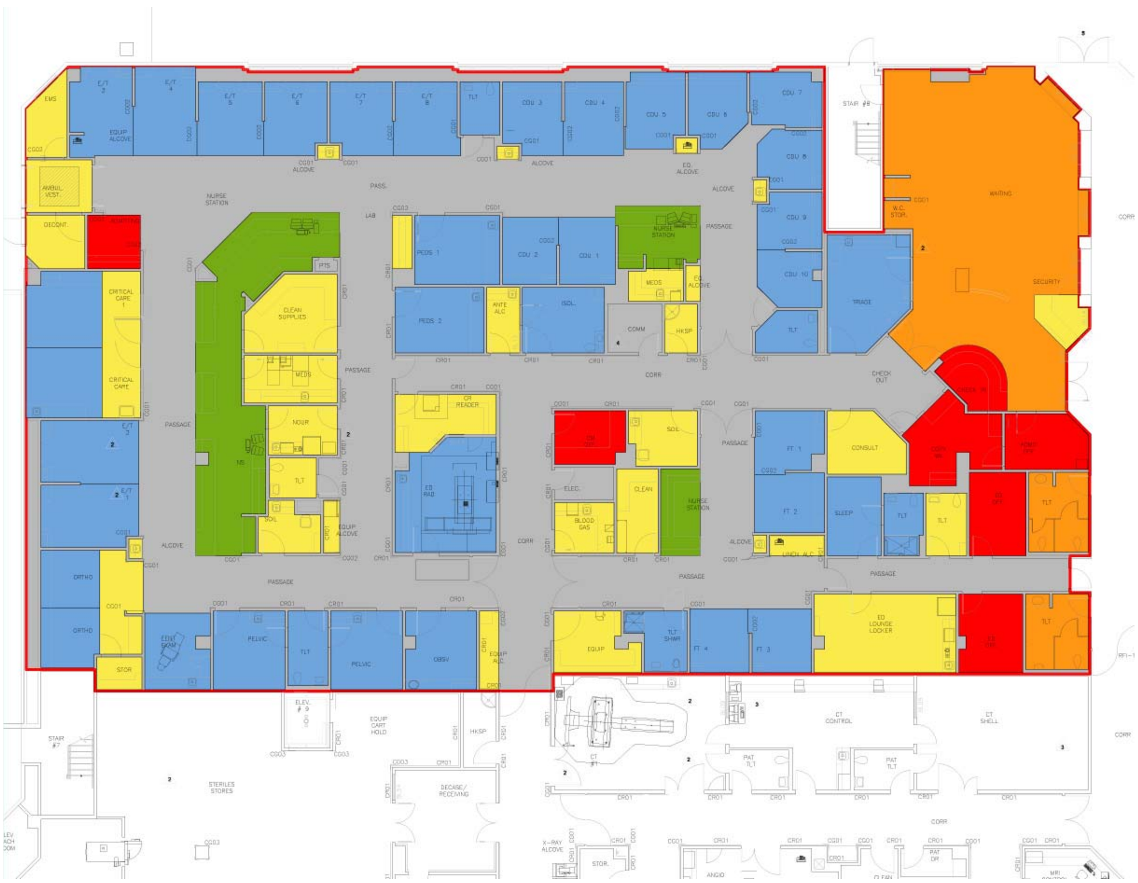


Figure 11: St. Rose (8,136.74 SF)

The mean ratio of net square feet to departmental gross was 1.58, with a standard deviation of .11. The mean ratio is best illustrated in the sample pool by the St. Rose San Martin ED at 14,751 DGSF with a net to gross ratio of 1.57.

Of particular interest in this initial sample is the difference in the ratio between large and small emergency facilities. The ratio for the nine emergency services smaller than 20,000 DGSF was 1.53 while the ratio for the nine larger ER's was 1.62. This may be explained by two factors. First, the waiting area in the smaller units contributed to a larger proportion of the total area than for larger emergency facilities. Since all of the waiting area was counted as net square feet, this contributed to a portion of the variance. What appears to be more significant is the development of clusters, or "pods," of special components in the larger design, resulting in small groupings of treatment area with significant circulation components. This is a significant issue, since emergency facilities have been increasing in size over the past twenty years as a result of volume and service growth. If a larger sample supports this finding, the development of a "sliding" scale may be appropriate for the net to gross ratio based on the overall size, or volume, of the unit. The mean result of 1.58 and 1.63 for larger units is notably close to the previous 1.6 rule-of-thumb ratio used by many practitioners.

Figure 12: Alegent Lakeside Emergency Department (10,352 SF)

Figure 13: Sacred Heart Medical Center Emergency Department (31,498 SF)

Unfortunately, there were no "perimeter" corridor configurations in this initial sample. The perimeter model has been seen in some recent designs. It presents challenges in the measurement of a DGSF ratio, particularly as to the determination of what components of the "inner-core" staff work area should be credited as net versus gross. It is hoped that future samples will include this design type.

Fig 14: Comprehensive Emergency Department List

Analysis of Emergency Departments in Contemporary Hospitals

HOSPITAL	FIRM	CITY	STATE	Ratio	DGSF
Sacred Heart Medical Center at Riverbend	Anshen + Allen	St. George	Utah	1.57	31,498 SF
Baptist Health Medical Center	HKS	North Little Rock	Arkansas	1.54	8,868 SF
Centennial Hills Hospital Medical Center	HKS	Las Vegas	Nevada	1.48	21,615 SF
George Washington University Hospital	HKS	Washington	D.C.	1.39	17,392 SF
Homestead Hospital	HKS	Homestead	Florida	1.54	26,115 SF
Laredo Medical Center	HKS	Laredo	Texas	1.54	7,944 SF
Obici Hospital	HKS	Suffolk	Virginia	1.47	11,412 SF
Spring Valley Hospital Medical Center	HKS	Las Vegas	Nevada	1.60	20,001 SF
St. Rose San Martin	HKS	Las Vegas	Nevada	1.57	14,751 SF
Temecula Medical Center	HKS	Temecula	California	1.48	18,977 SF
Alegent Lakeside Hospital	Leo Daly	Omaha	Nebraska	1.55	10,352 SF
UC Davis Medical Center	Chong Partners	Sacramento	California	1.66	40,850 SF
Lakeland Regional Medical Center	HLM	Lakeland	Florida	1.61	29,079 SF
Blind 1	blinded	blinded	California	1.77	20,403 SF
Blind 2	blinded	blinded	California	1.75	11,408 SF
Blind 3	Smith Group	Los Angeles	California	1.65	30,164 SF
St. John's	Smith Group	Culver City	California	1.77	20,894 SF
Providence St. Josephs Medical Center	Smith Group	blinded	blinded	1.52	14,055 SF

n	18	
Mean	1.58	19,765 SF
Minimum	1.39	7,944 SF
Maximum	1.77	40,850 SF
St'd. Deviation	0.11	8,988 SF

Findings: Imaging

Eighteen imaging departments were examined ranging in size from 10,675 DGSF to 27, 632 DGSF. The plans represent examples of centralized work cores serving several imaging rooms, multiple work cores and dispersed staff work or support areas. Most provided a comprehensive range of imaging modalities from MRI and CT to R/F and ultrasound. Some included nuclear imaging modalities and some included shelled-in rooms which were counted as net square feet only if the rooms were designed and within the operational departmental boundary.

The net to gross ratios in the study pool ranged from 1.34 at George Washington Hospital to 1.67 at Providence St Joseph's Medical Center. Both departments are of comparable size and fall close to the mean area of 19,693 DGSF. The 19,269 DGSF department at George Washington is organized with most imaging rooms or suites accessed off a single, double loaded corridor and a large number of support or administrative spaces accessed through another net functional space. It also shares a corridor with an adjoining department in which only half the areas were counted toward Imaging.

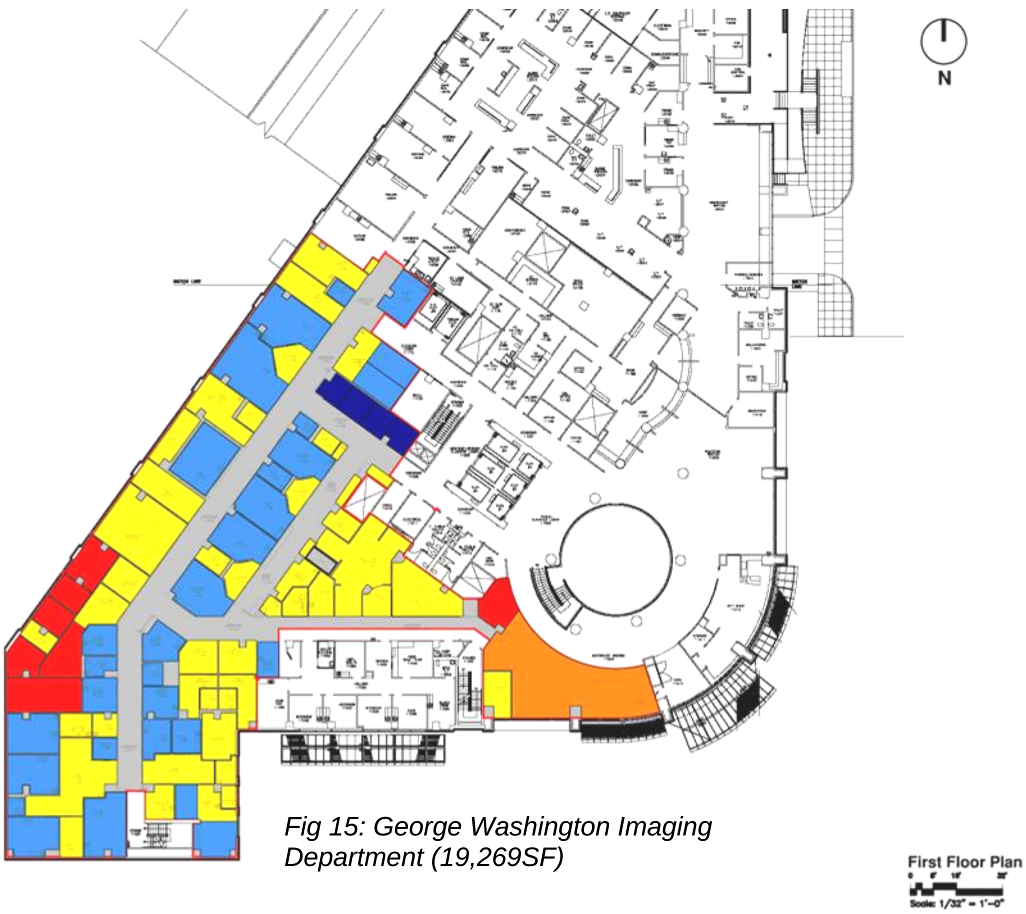


Fig 15: George Washington Imaging Department (19,269SF)

Conversely, the 20,204 DGSF department at Providence St. Joseph's Medical Center is characterized by a narrow dogleg extension that wraps around another department. It is also characterized by a large percentage of single loaded corridors serving functional areas within the department. In several instances columns fall within the corridor creating the need for wider corridors in order to maintain a minimum 8 foot clear width at the columns. There are several instances in this plan where alcoves have been created in the corridor further increasing the proportion of space designated as circulation.

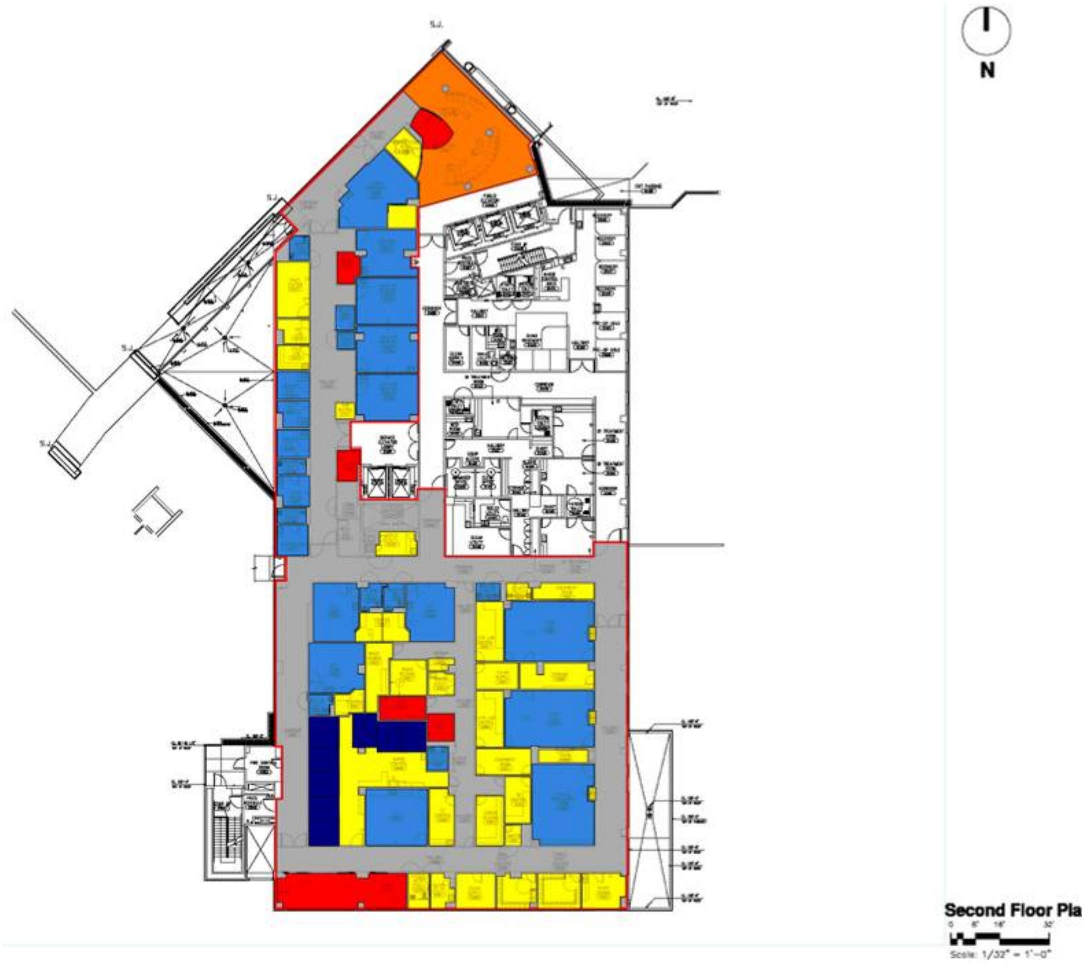


Fig 16: Providence St. Joseph's Medical Center (20,204 SF)

Imaging: mean ratio of NSF to DGSF gross = 1.53 (n=17)

The mean net to gross ratio is best represented by the imaging departments at Obici and Laredo, each at 1.53, and respectively the largest and smallest departments in the sample. This indicates that departmental size had no identifiable relationship with the net to gross ratios in the sample. As the two preceding examples illustrate, variations in net to gross ratios apparently had more to do with departmental configuration and circulation planning strategies.

Several departmental plans stood out to the researchers as being representative of the range in net to gross factors or representative of high, low and median net to gross ratios.

Project	Firm	Key feature	DGSF/NSF	DGSF
St Rose	HKS		1.41	17,457
Blind 3	SmithGroup		1.51	25,141
Sacred Heart	A+A	10 rms - work core	1.52	19,597
Obici	HKS	large	1.53	27,632
St. Johns	SmithGroup		1.62	25,984

Figure 17: Comprehensive Imaging Department List

Analysis of Imaging Departments in Contemporary Hospitals					
HOSPITAL	FIRM	CITY	STATE	Ratio	DGSF
Sacred Heart Medical Center at Riverbend	Anshen + Allen	Springfield	Oregon	1.52	19,597 SF
Baptist Health Medical Center	HKS	North Little Rock	Arkansas	1.44	22,484 SF
Centennial Hills Hospital Medical Center	HKS	Las Vegas	Nevada	1.64	19,523 SF
George Washington University Hospital	HKS	Washington	D.C.	1.34	19,269 SF
Homestead Hospital	HKS	Homestead	Florida	1.50	15,590 SF
Laredo Medical Center	HKS	Laredo	Texas	1.53	10,675 SF
Obici Hospital	HKS	Suffolk	Virginia	1.53	27,632 SF
Spring Valley Hospital Medical Center	HKS	Las Vegas	Nevada	1.42	24,733 SF
St. Rose San Martin	HKS	Las Vegas	Nevada	1.41	17,457 SF
Temecula Medical Center	HKS	Temecula	California	1.61	17,129 SF
Alegent Lakeside Hospital	Leo Daly	Omaha	Nebraska	1.57	19,348 SF
UC Davis Medical Center	Chong Partners	Sacramento	California	1.47	15,849 SF
Blind 1	blinded	blinded	California	1.56	11,345 SF
Blind2	blinded	blinded	California	1.60	22,812 SF
Blind 3	Smith Group	Los Angeles	California	1.51	25,141 SF
Providence St. Josephs Medical Center	Smith Group	blinded	blinded	1.67	20,204 SF
St. John's	Smith Group	Culver City	California	1.62	25,984 SF

n	17	
Mean	1.53	19,693 SF
Minimum	1.34	10,675 SF
Maximum	1.67	27,632 SF
St'd. Deviation	0.09	4,809 SF

Findings: Surgery

The nineteen surgery departments studied ranged in size from 97,524 DGSF at Sacred Heart Medical Center to 17,650 DGSF at Laredo. The sample pool included plans with a single clean core, multiple clean cores, single loaded clean cores, and single corridor schemes with sub-sterile rooms. Clean cores ranged from large areas capable of handling ample case cart storage to smaller cores with remote clean holding areas. The surgery department area take-offs include PACU as part of Surgery. Several of the departments examined included endoscopy and other special procedure rooms. Individual rooms were included when they were clearly within the departmental boundary, but extensive endoscopy suites or departments were excluded when they could be identified as distinct units.

The net to gross ratios ranged from a low of 1.46 at UC Davis to a high of 1.80 at Providence St. Joseph's Medical Center. The UC Davis plan is one of the larger departments in the pool at 78,109 DGSF and is unique in the sample in that it has both multiple clean cores and contains a large case cart holding area on another floor [not shown] This area is accessed through elevators in each clean core. This remote storage area is included in the departmental net and gross areas. The elevators were not considered part of the departmental area as it could not be determined if they were dedicated to surgery and several arrived outside the departmental area on the other floor. Waiting areas are separated from the main departmental area by an interdepartmental thoroughfare. The large size, efficient layout, minimal single loaded corridors and the features mentioned above would appear to contribute to its efficient net to gross ratio.

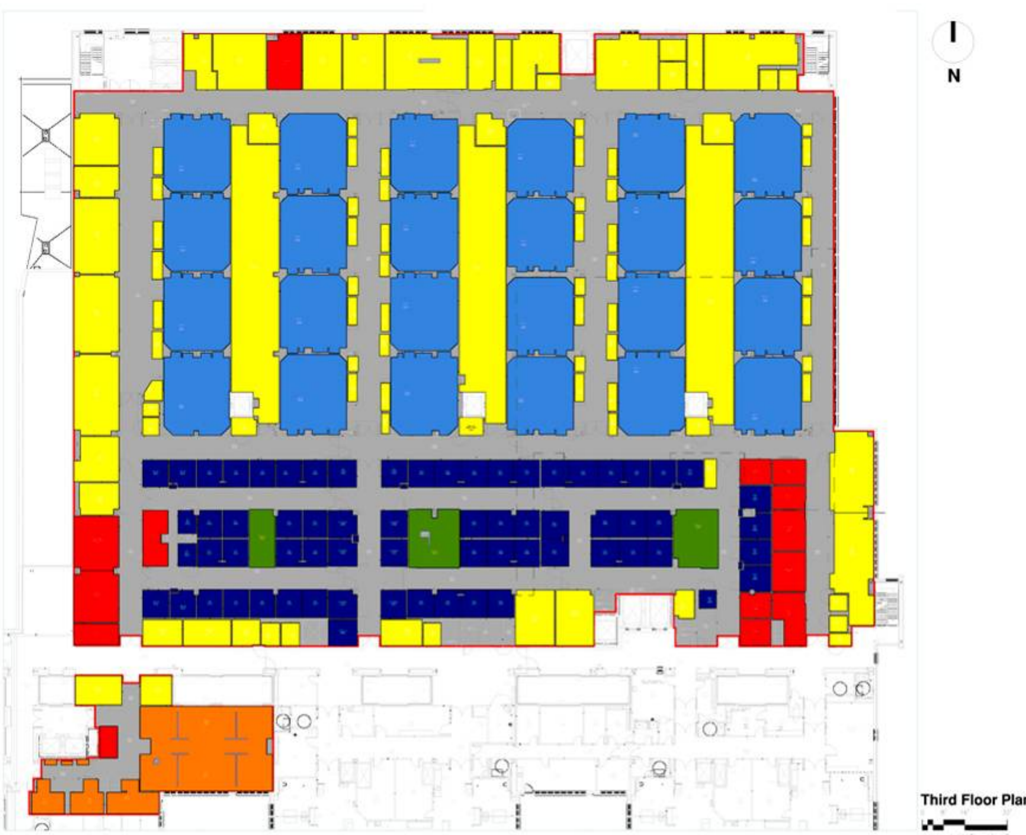


Figure 18: UC-Davis Surgical Department (78,109 SF)

The Providence St. Joseph's Medical Center surgery department at 19,813 DGSF is one of the smaller surgical departments studied. It shares the same characteristics as the Imaging department in this facility. Both have an articulated plan layout where a dogleg extension of the department [in this case PACU] wraps around another departmental area. As in Imaging, the main procedure areas of the department are wrapped in a single loaded corridor. Unlike imaging however, the space between columns along the perimeter clean corridor is dedicated for equipment storage so it has been counted as net square feet. The articulated shape of the department and large amount of perimeter single loaded corridor contribute to its 1.80 net to gross ratio.

Fig 19: Providence St. Joseph's Medical Center (19,813 SF)

Surgery: mean ratio of NSF to DGSF gross = 1.61 (n=19)

Each of the departments with a net to gross ratio nearest the mean of 1.61 [Spring Valley, Alegent Lakeside, and Homestead] have planning characteristics that distinguish them from pure planning diagrams. All three also have shelled ORs or procedure rooms and support spaces within the department that were included in the departmental and net areas. Alegent is planned such that a single corridor surgery suite wraps two side of its PACU. Homestead is a J-shaped surgery that wraps around a central court or atrium.

Figure 20: Homestead Surgery (28,882 SF)

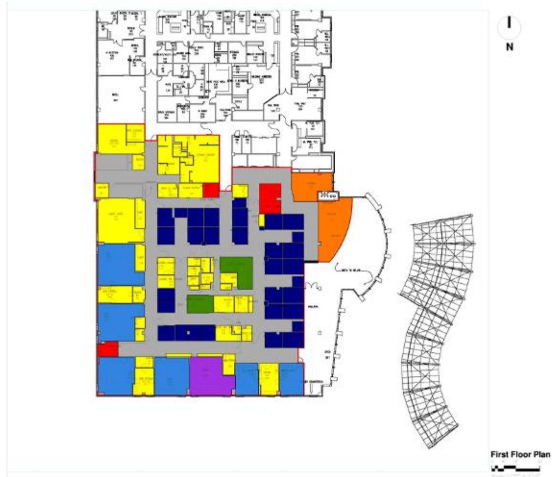


Figure 21: Alegent Lakeside Surgery (24,332 SF)

The mean net to gross ratio is perhaps best represented by the Surgery at Spring Valley with a departmental net to gross ratio of 1.59. It is characterized by an E-shaped single corridor concept providing access to ORs with sub-sterile rooms. Other support areas are located within the department but somewhat remote from the ORs. The PACU appears designed to accommodate the full compliment of outfitted and shelled ORs indicated in the plan. The first floor location allows the branch corridors of the E configuration to function as dead-end corridors with emergency egress doors thus reducing the circulation that would be needed for this configuration on an upper floor.

Figure 22: Spring Valley Surgery (24,648 SF)

Another plan of note is Sacred Heart Medical Center which is the largest in the sample studied at 97,524 DGSF and has one of the largest net to gross ratios at 1.78. Several planning attributes may contribute to the higher net to gross ratio in this department including the standardized clustering of OR's into many 4 room suites, the integration of a four room image guided surgery suite, and the embedding of a large Endoscopy unit [not counted] within surgery. This may indicate that surgical departments designed for the increased integration of image guided procedures may require higher net to gross ratios.

Figure 23: Sacred Heart Medical Center Surgery (97,524 SF)

Several departmental plans for Surgery stood out as being of a wide range in net to gross factors and representative of high, low, and median net to gross ratios.

Project	Firm	Key feature	DGSF/NSF	DGSF
Blind 2	NA	clean core	1.49	23,769
George Washington	HKS	single corridor	1.51	34,769
St. John's	Smith Group	single loaded	1.55	40,134
Dixie Regional	A+A	clean core	1.65	38,419
Centenial	HKS	clean core	1.69	29,166
Temecula	HKS	wide corridors	1.79	29,543

Figure 24: Comprehensive Surgery Department List

Analysis of Surgery Departments in Contemporary Hospitals					
HOSPITAL	FIRM	CITY	STATE	Ratio	DGSF
Dixie Regional Medical Center	Anshen + Allen	St. George	Utah	1.65	38,419 SF
Sacred Heart Medical Center at Riverbend	Anshen + Allen	Springfield	Oregon	1.78	97,524 SF
UC Davis Medical Center	Chong Partners	Sacramento	California	1.46	78,109 SF
Baptist Health Medical Center	HKS	North Little Rock	Arkansas	1.58	30,408 SF
Centennial Hills Hospital Medical Center	HKS	Las Vegas	Nevada	1.69	29,166 SF
George Washington University Hospital	HKS	Washington	D.C.	1.51	34,769 SF
Homestead Hospital	HKS	Homestead	Florida	1.61	28,882 SF
Laredo Medical Center	HKS	Laredo	Texas	1.67	17,650 SF
Obici Hospital	HKS	Suffolk	Virginia	1.55	31,469 SF
Spring Valley Hospital Medical Center	HKS	Las Vegas	Nevada	1.59	24,648 SF
St. Rose San Martin	HKS	Las Vegas	Nevada	1.53	29,135 SF
Temecula Medical Center	HKS	Temecula	California	1.79	29,650 SF
Alegent Lakeside Hospital	Leo Daly	Omaha	Nebraska	1.59	24,332 SF
Blind 1	blinded	blinded	California	1.57	31,199 SF
Blind 2	blinded	blinded	California	1.49	23,769 SF
Blind 3	Smith Group	blinded	California	1.62	65,603 SF
Providence St. Josephs Medical Center	Smith Group	blinded	blinded	1.80	19,813 SF
St. John's	Smith Group	Culver City	California	1.55	40,134 SF
Physicians Hospital of El Pas(	Philo + Wilke	El Paso	Texas	1.51	20,410 SF

n	19	
Mean	1.61	36,584 SF
Minimum	1.46	17,650 SF
Maximum	1.80	97,524 SF
St'd. Deviation	0.10	21,041 SF

Findings: Intensive Care Units (ICU)

The nineteen ICU departments studied ranged in size from a twelve room single suite of 6,280 DGSF at Obici to a combined 34 bed ICU floor of 33,263 DGSF at St. John's. The sample pool included plans with racetrack layouts, triangular plans, single and multiple suites, and a perimeter corridor concept. Most of the ICUs studied involved multiple adjoining suites where support spaces were often shared. The study group involved a mix of units designed with clearly separate suites and large contiguous units with multiple staff areas.

The highest net to gross ratio found was 1.96 at Providence Hospital Northeast which involved a perimeter access corridor for families and a central staff work area, along with separate 8 foot wide staff and patient corridors. This planning concept obviously contributes to its high ratio.

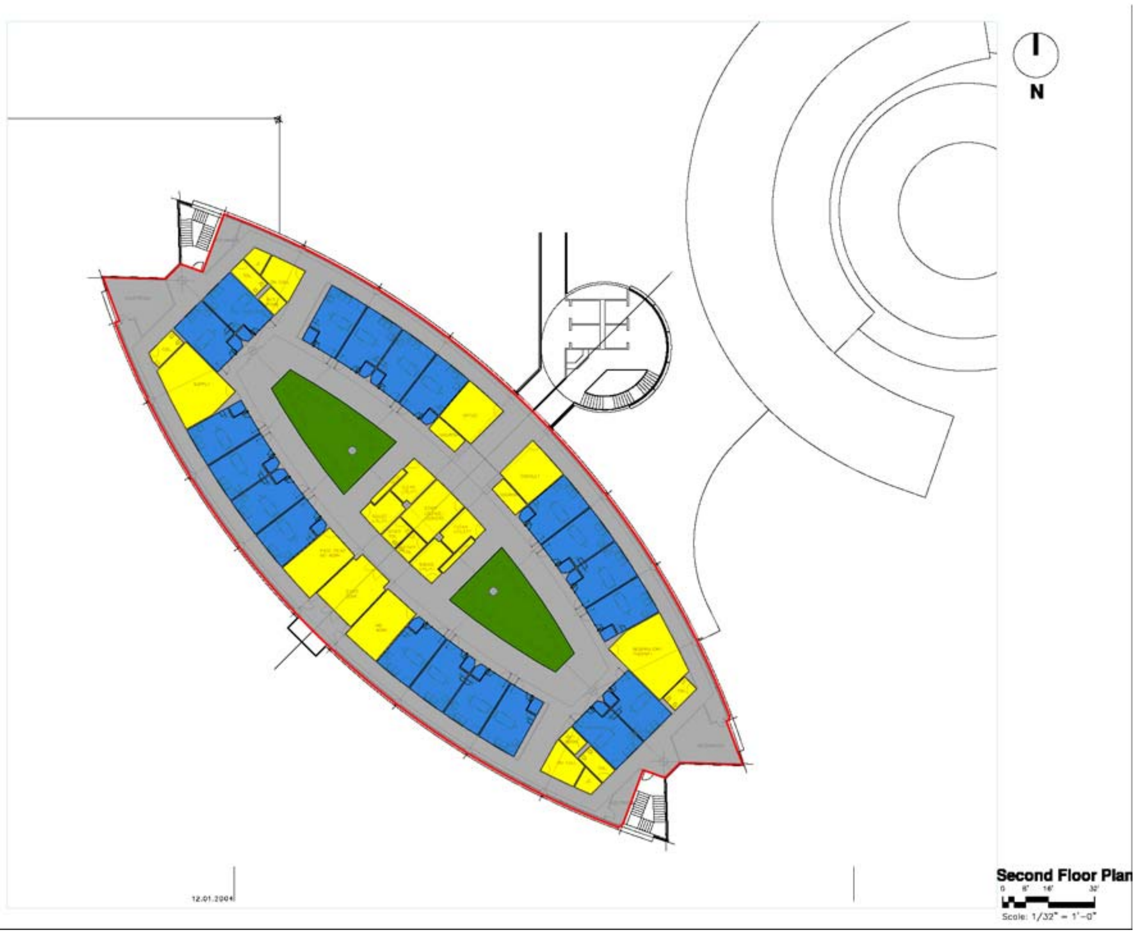


Figure 25: Providence Hospital Northeast Intensive Care (22,665 SF)

The lowest net to gross ratio at 1.34 was found at George Washington University Hospital, a single suite unit with 12 beds arranged in a triangular shaped suite. A single corridor provides access to all rooms and support spaces and obviously contributes to the low net to gross ratio in this plan. The inherent geometric properties of this triangular shaped plan also allows a greater perimeter wall area [both exterior and interior] containing a minimal amount of overall floor area of 8,137 DGSF enabling a high ratio of rooms around the perimeter compared to the overall floor area of the department. The compact floor area at with the central corridor also contributes to its low net to gross ratio as a larger footprint would almost inevitably involve more circulation. The smaller units configured as single suites of 10-12 beds in the sample fell below the mean net to gross ratio.

Figure 26: George Washington Intensive Care (8,137 SF)

Other unit configurations that consistently fell below the mean net to gross ratio included multiple suites configured within larger race track floor plans similar to conventional Acute Care Units. This is most clearly represented by Centennial Hills, a multi unit plan of 32 beds, 21,973 DGSF and a 1.46 net to gross ratio.

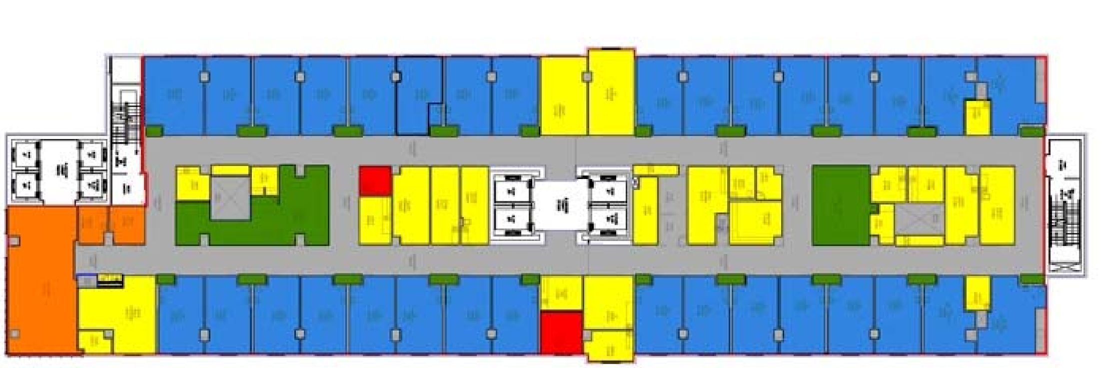


Figure 27: Centennial Hills Intensive Care (21,973 SF)

Intensive Care: mean ratio of NSF to DGSF gross = 1.56 (n=19)

The mean ratio of 1.56 is best represented by Blind 1 and Sacred Heart Medical Center. Blind 1 is another triangular shaped unit with a net to gross ratio of 1.58. It is larger than George Washington at 20 beds and 16,504 DGSF and is configured into two suites. In this case there is a higher ratio of administrative space within the unit as well as a large number of corridor alcoves. Sacred Heart Medical Center is a comparably sized unit at 17,605 DGSF with two distinct triangular suites and a 1.57 net to gross ratio. Many of the units in the sample pool with clearly distinct suites similar to Sacred Heart Medical Center fell in range just above the mean and up to a 1.64 net to gross ratio.

Figure 28: Blind 1 (16,504 SF)

Figure 29: Sacred Heart Medical Center Intensive Care (17,605 SF)

Other Intensive Care units represented the wide range in net to gross ratios.

Project	Firm	Key feature	DGSF/NSF	DGSF
Obici	HKS	12 room suite	1.49	6,280
UC Davis	Chong	20 room suite	1.59	18,219
Blind 3	Smithgroup	16 room suite	1.76	19,279

Figure 30: Comprehensive Intensive Care Department List

Analysis of Intensive Care Departments in Contemporary Hospitals

HOSPITAL	FIRM	CITY	STATE	Ratio 2	DGSF
Dixie Regional Medical Center	Anshen + Allen	St. George	Utah	1.51	16,904 SF
Sacred Heart Medical Center at Riverbend	Anshen + Allen	Springfield	Oregon	1.57	17,605 SF
UC Davis Medical Center	Chong Partners	Sacramento	California	1.59	18,158 SF
Centennial Hills Hospital Medical Center	HKS	Las Vegas	Nevada	1.46	21,973 SF
George Washington University Hospital	HKS	Washington	D.C.	1.34	8,137 SF
Homestead Hospital	HKS	Homestead	Florida	1.41	12,674 SF
Laredo Medical Center	HKS	Laredo	Texas	1.64	9,569 SF
Obici Hospital	HKS	Suffolk	Virginia	1.49	6,280 SF
St. Rose San Martin	HKS	Las Vegas	Nevada	1.46	8,459 SF
Spring Valley Hospital Medical Center	HKS	Las Vegas	Nevada	1.44	24,738 SF
Temecula Medical Center	HKS	Temecula	California	1.53	24,130 SF
Blind 1	blinded	blinded	California	1.58	16,504 SF
Blind 2	blinded	blinded	California	1.62	12,882 SF
Providence Hospital Northeast	HLM	Columbia	South Carolina	1.96	22,665 SF
Region West	HLM	Fort Collins	Colorado	1.47	22,223 SF
Blind 3	Smith Group	Los Angeles	California	1.74	11,760 SF
Blind 3	Smith Group	Los Angeles	California	1.76	19,279 SF
Providence St. Josephs Medical Center	Smith Group	blinded	blinded	1.42	6,658 SF
St. John's	Smith Group	Culver City	California	1.62	33,263 SF

n	19	
Mean	1.56	16,498 SF
Minimum	1.34	6,280 SF
Maximum	1.96	33,263 SF
St'd. Deviation	0.15	7,279 SF

Findings: Acute Inpatient Units

The eighteen Acute Inpatient units studied ranged in size from a 12 bed unit of 9,502 DGSF at Region West to a combined 48 bed floor of 32,726 DGSF at St. Johns. The sample pool was dominated by mostly conventional racetrack and triangular unit plans, with several hybrid racetracks with double loaded corridor extensions and one double-loaded single corridor plan. The sample includes a mix of easily identifiable single nursing units and plans that may be operated as multiple units with shared support spaces. It was impossible within the scope of this study to determine the operating unit size from the documents. When one unit was clearly self contained and separated physically, it was studied on its own. In many cases large units appeared to share common support functions and were measured as one unit. This yielded the significant range in both unit floor area and bed or room count.

While not central to this study, the DGSF per bed ratio in the Acute Care sample was examined along with the net to gross ratio. Efficiency in acute care units may be measured in terms of both the net to gross ratio, and DGSF per bed. These ratios did not necessarily match in the study group, except that the unit with highest net to gross ratio also had one of the higher DGSF/bed ratios [708 SF], and the unit with the lowest net to gross ratio had the lowest DGSF/bed ratio [353 SF]. The smallest unit – 12 beds - stood out for having one of the lower net to gross ratios [1.44] and the highest DGSF/bed ratio [792 SF]. The average DGSF/bed ratio across the sample pool was 598 SF per bed.

The highest net to gross ratio found was 1.79 at Providence Hospital Northeast which is a bowed racetrack plan with what appears to be large central open areas. These open areas were counted in the DGSF. This planning concept obviously contributes to its high ratio.

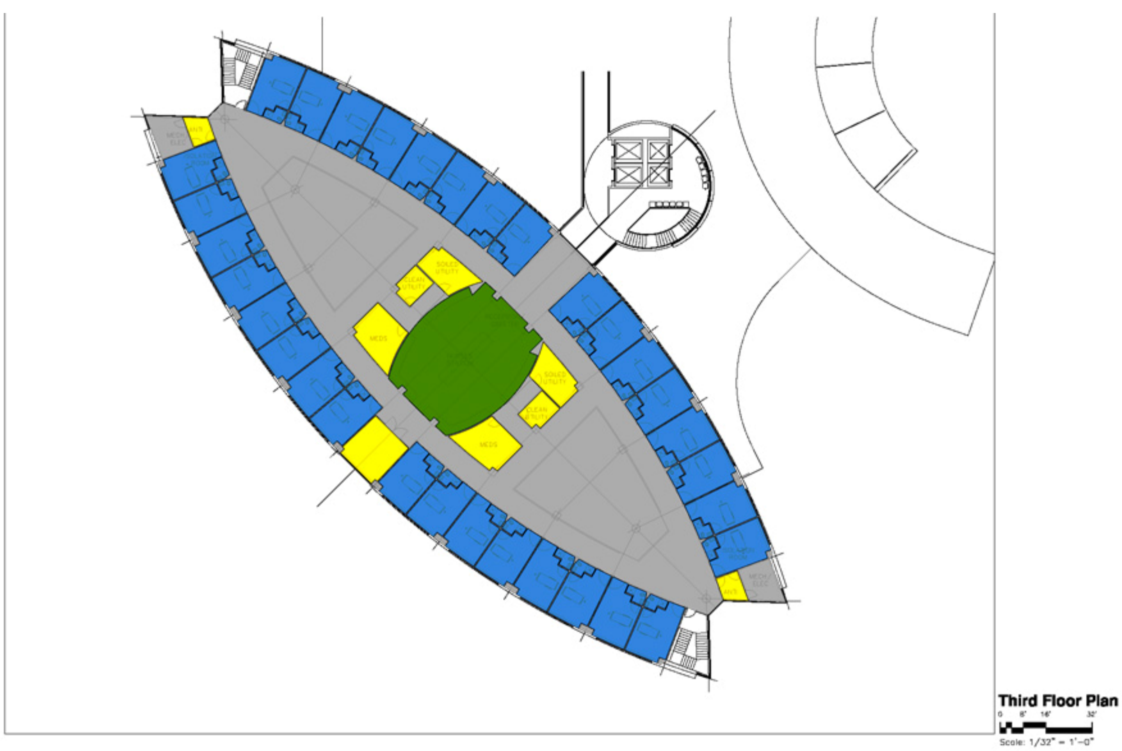


Figure 31: Providence Hospital Northeast = 1.79/22,665 DGSF

The lowest net to gross ratio of 1.39 was again found at George Washington University Hospital. In addition, this unit had a 353 DGSF/bed ratio which fell well below the next lowest ratio of 456 DGSF/bed. There appear to be multiple factors which lead to this unit's high efficiency. It is both a triangular plan layout with a compact support core and one with patient room clusters. This 44 bed unit is also one of the hybrid private and semi-private room units with the highest number [15] of semi-private rooms. Finally, this triangular plan has corridors only along two sides of the triangle and many of the double rooms are located along a double loaded corridor extension.

Figure 32: George Washington University Hospital = 1.39/15,540 DGSF

Another unit with a very low net to gross ratio was Baptist Health Medical Center at 1.41. As at George Washington, its triangular floor plan has rooms and corridors on only two sides. However, unlike GW, the Baptist unit consists of all private rooms which are not organized into clusters or pods. This suggests that, in these two instances, the shape and circulation patterns of the units contribute more to their efficiency than the use of semi-private rooms or clusters.

Acute Inpatient Care: mean ratio of NSF to DGSF = 1.56 (n =18)

The mean net to gross ratio of 1.56 for inpatient units can be seen at one of the blinded hospitals, Blind 3. Two separate inpatient acute care units were included from this hospital with similar characteristics. The second unit had a net to gross ratio of 1.54. They are both hybrid racetrack plans with double-loaded corridors [patients on both sides of a single corridor] extending from a racetrack configuration with a central support core. Each of these 32 bed units also has 4 semi-private rooms. Both of these conditions help improve the efficiency of these units and yielded a well below average 467 DGSF/bed and 456 DGSF/bed, respectively. At the same time, one characteristic that increased their DGSF is that they both have extensive space dedicated to shafts within their cores.

Figure 33: Blind 3 = 1.56/14,947 DGSF

As mentioned, the most common unit configuration was the racetrack plan where 9 of the 18 units in the sample fell under this classification. Discounting the 12 bed racetrack plan at Region West, the net to gross ratio within this type varied from 1.71 to 1.55 and this sample ranged from 752 DGSF/bed to 515 DGSF/bed.

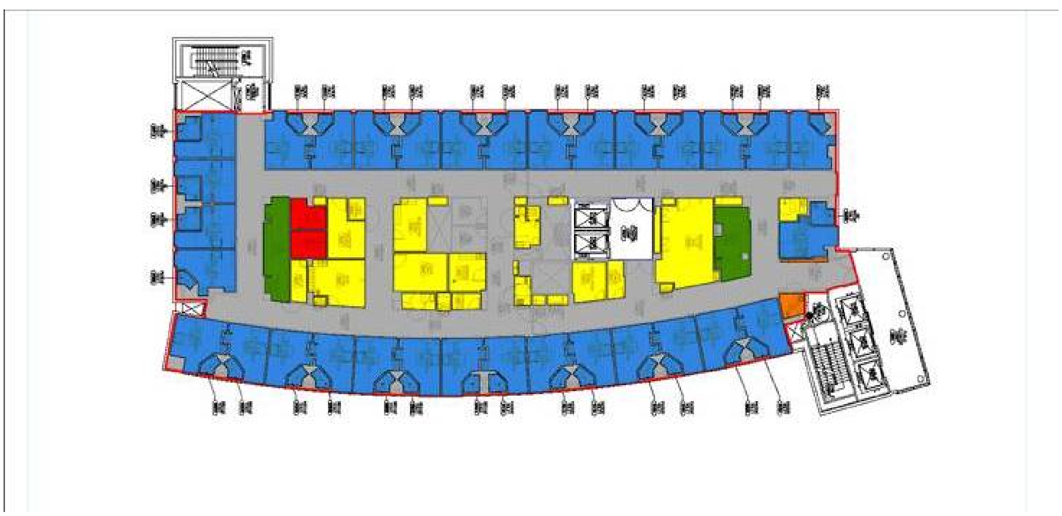


Figure 34: Providence St. Joseph's Medical Center = 1.71/16, 494 DGSF

Providence St. Joseph's represents an example of a 32 bed, all private room, racetrack unit plan. It falls near the highest net to gross ration at 1.71. At the same time it is well below average for DGSF/per bed at 515 SF. This unit has a large amount of shaft space within its core counted as DGSF and, as with many racetrack plans, contains an internal elevator core not counted as DGSF.

Spring Valley is basically similar in configuration to St. Joseph's but with significantly different results. It is a racetrack plan of 35 private rooms with an elevator core at one end and internal mechanical shafts. It is larger in DGSF at 21,390 SF and falls close to the mean net to gross ratio at 1.55, lower than St. Joseph's. At the same time it has a higher DGSF/bed ratio of 611 SF.

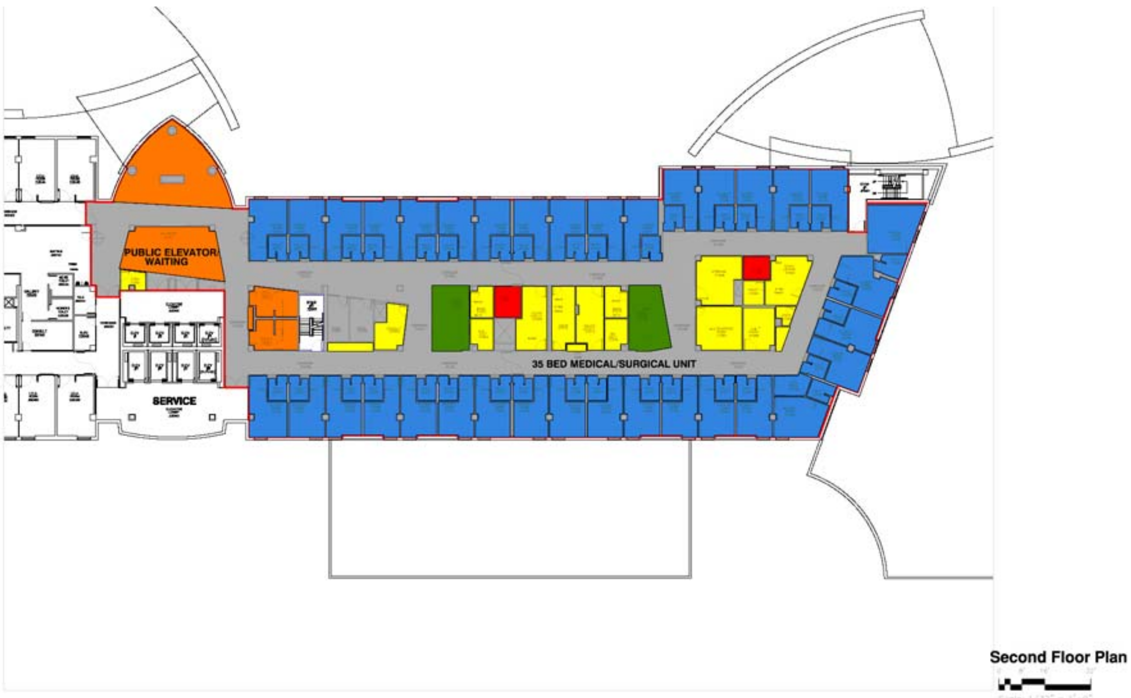


Figure 35: Spring Valley Hospital Medical Center = 1.55/21,390 DGSF

Blind 1 represents a more typical triangular unit design than George Washington with rooms and corridors on all three sides. This 24 bed all private room unit falls above the mean with a 1.62 net to gross ratio and below the DGSF mean at 17,726 SF. The DGSF would be lower if the lower corridor was not counted.

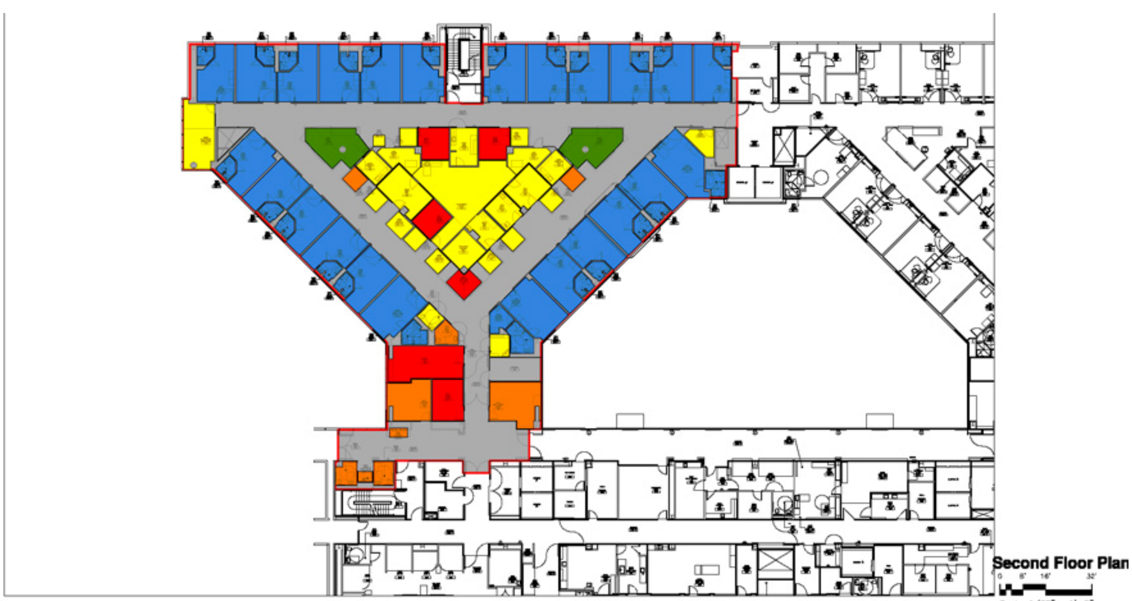


Figure 36: Blind 1 = 1.62/17,726 DGSF

Given the sample size and variations in net to gross ratio, unit size, DGSF/bed, number of beds, and configuration, the researchers were unable to discern any significant relationships between the variables. However, it was noted that the smaller units in the sample tended to be more efficient in terms of net to gross ratio, but not necessarily in terms of DGSF/bed.

Figure 37: Acute Care Department Summary

Analysis of Inpatient Departments in Contemporary Hospitals

HOSPITAL	FIRM	CITY	STATE	Ratio	DGSF
Sacred Heart Medical Center at Riverbend	Anshen + Allen	Springfield	Oregon	1.68	22,202 SF
Baptist Health Medical Center	HKS	North Little Rock	Arkansas	1.41	9,767 SF
Centennial Hills Hospital Medical Center	HKS	Las Vegas	Nevada	1.53	22,102 SF
George Washington University Hospital	HKS	Washington	D.C.	1.39	15,540 SF
Homestead Hospital	HKS	Homestead	Florida	1.49	24,349 SF
Obici Hospital	HKS	Suffolk	Virginia	1.61	22,477 SF
Spring Valley Hospital Medical Center	HKS	Las Vegas	Nevada	1.55	21,390 SF
Alegent Lakeside Hospital	Leo Daly	Omaha	Nebraska	1.52	24,076 SF
Blind 1	blinded	blinded	California	1.62	17,726 SF
Blind 2	blinded	blinded	California	1.50	10,951 SF
Providence Hospital Northeast	HLM	Columbia	South Carolina	1.79	22,665 SF
Region West	HLM	Fort Collins	Colorado	1.44	9,502 SF
Lakeland Regional Medical Center	HLM	Lakeland	Florida	1.61	28,988 SF
Blind 3	Smith Group	Los Angeles	California	1.56	14,947 SF
Blind 3	Smith Group	Los Angeles	California	1.54	14,599 SF
Providence St. Josephs Medical Center	Smith Group	blinded	blinded	1.71	16,494 SF
St. John's	Smith Group	Culver City	California	1.60	32,726 SF
Physicians Hospital of El Paso	Philo + Wilke	El Paso	Texas	1.46	11,922 SF

n	18.00	
Mean	1.56	19,024 SF
Minimum	1.39	9,502 SF
Maximum	1.79	32,726 SF
St'd. Deviation	0.10	6,596 SF

Limitations of the Study

As a pilot study, the data gathered in this study and the findings are potentially important. There are, however, limitations to the usefulness of the study which should be addressed in future studies.

Small Sample Size: The study is of necessity based on a small sample size. While numerous firms were asked to participate, only a small number contributed CAD drawings for the purposes of the study, and some of those arrived quite late in the study period. While the total number of department calculations in the study is fairly sizeable, the number in any single departmental category is small and the number of participating firms is small. One firm alone provided plans for ten of the hospitals studied – half the sample. The number of the sample [n] and the emphasis on plans from one firm reduces the ability to generalize and reliability of the study findings, as does the variation in project types within the small sample.

Reluctance to Participate: Some firms with projects that would have been important to study did not elect to participate. Some were apparently concerned that information they perceived as proprietary might be released in ways that would put them at a competitive disadvantage. Still other firms indicated difficulties securing permission from their clients to release plans for the study. For a combination of reasons, the number of participating firms was disappointing, and future studies would do well to recruit participants early and aggressively.

Types of Projects Reviewed: The range of types from small, rural facilities to community hospitals and huge academic medical centers makes direct comparison of the findings somewhat problematic unless they can be sorted by categories, and that would result in even smaller sample sizes. Other ways to differentiate and analyze the data would recognize the difference between government, private not-for-profit, and investor-owned facilities. Again, the problem is the lack of sufficient numbers of examples in each sample population.

Inconsistent Calculation Methodology: The investigators were surprised at the apparent broad variation in calculation methodologies when experienced practitioners were asked to make judgments about specific questionable cases. It became apparent that experienced practitioners in everyday practice may be using common language about these important ratios while unknowingly using slightly different criteria for the calculations each actually performs. They may use the same words to mean something different while unaware of the variation. Firms were not asked to provide information on their own calculation methodology. Future studies should request that the firms explicitly document and share their calculation model.

Absence of Data Relating to Programmed Ratios: The study was not structured to ask detailed questions of the participating firms. For this reason, the researchers did not have access to data that could have answered important questions: 1) what was the programmed target net-to-gross ratio for each department? 2) what was the firm's calculation of the resulting ratio? And 3) what would the firm have considered an ideal ratio for that specific project? In each case, the researchers do not know whether the architects agreed with the target ratio, or whether they were satisfied with the result.

Absence of Data Relating to Design Intent: The researchers had no documentation of the program, the design intent, post-occupancy evaluation, or the perception of the plan's performance. Was the program written by the architect, or an independent consultant? Did the client demand a particularly frugal use of space? Was a design layout unique, or typical? Was the architect able to easily meet the program, or were compromises and undesirable cuts required to keep the project in the budget?

Absence of Data Reflecting the Performance of the Departments Measured: The researchers had no access to performance metrics associated with the departments measured in this study. It could be useful to know whether departments with particular net-to-gross ratios performed better or worse than departments with similar or different ratios. Architects and owners would surely like to know if higher ratios were correlated with higher performance, or not.

Time Lag Between Design and Occupancy: Healthcare projects, especially hospital projects, require considerable planning, design, and construction time. The decision to review completed projects has therefore produced a study of designs from at least 3-5 years ago. This may mean that the study is not fully capable of addressing the question of what contemporary architects, programmers, and consultants are doing in practice today.

Discussion

This pilot study produced interesting data and raised interesting questions. While the implications of the study's limitations must be kept in mind, practitioners will be able to compare their own projects to those in the study. Practitioners will be able to compare the findings, along with their own evaluations of the departmental planning associated with the specific designs, to their own projects in potentially meaningful ways.

The mean net to gross ratio for the area calculations associated with each of these major hospital departments was fairly similar to the rules of thumb from a decade ago. This could suggest that the requirements for total area are changing while the ratio of net space to gross space is relatively unchanged. On the other hand, the variation in the range of observed ratios was high enough in some cases to challenge the assumption that the mean was a useful calculation.

It is important to note that the design of these hospital departments is profoundly influenced by regulatory constraints. The building codes, life safety requirements, and state hospital licensing standards mandate items such as corridor and stair widths, permissible numbers of fire stairs, and the like. These regulations have remained relatively stable during the period under study, perhaps influencing the tendency for the ratios studied to have remained less changed than might have been expected.

The study cast an important light on the methods used to calculate area in hospital projects. The researchers were surprised to discover the variation in calculation methodologies employed by experienced practitioners, and the literature provided few authoritative sources for such methods. Broadly applied methods, such as described in AIA D101-95, appear to lack sufficient detail to cover numerous cases in which practitioners must exercise their own judgment in order to complete a complex area calculation.

Questions Raised by the Study: A pilot study is expected to raise questions. This one raised many. Perhaps the first question is what might have been the results with a broader sample? Would the data be similar and would the conclusions be stronger? Another question is what might explain the observed range of ratios within each category of departments? The researchers would have liked to know what the designers believed about their designs: were they compact or generous, were they pressed to save space or budget, and did they perceive their designs as innovative? The researchers would like to know whether the designers met or exceeded the program. It could be instructive to know whether the departments studied were average, exemplary, or poor performers from the hospital administration's perspective.

Possibility of Alternative Theories: If the study results are less than absolutely conclusive, as in the case of the ratios for Emergency Services, there is a possibility that architects, programmers, and consultants have continued to use the old "rule-of-thumb" ratios of the past. If so, they may be delivering completed contemporary projects that are only slightly different from those designed in the past. If this were the case, those projects could 1) be completely appropriate, thus confirming the validity of older ratios, or 2) they could be inappropriate in some way, missing new design opportunities, but unrecognized as falling short. A different study model would be required to answer such a question.

Since all healthcare organizations are under financial pressure to contain costs, all capital projects bear an obligation to be efficient and as economical as possible. The architect or programmer of space requirements might be inclined to conform to prevailing (meaning older) standards, while the chief financial officer or bond counsel might also be requesting compliance with an outdated model based on historical area calculations.

Conclusions

Recommendations:

Based on a review of the literature and the current pilot study of area calculations for major hospital departments, while bearing in mind the limitations of the study, the researchers are confident that the following recommendations can be made:

1) The healthcare design and construction field clearly needs a more consistent and standardized method for area calculation and calculation of hospital departmental net-to-gross ratios.

    a. Such a standard should include standards for calculation of building gross (not covered in this study).

2) The proposed standard should conform closely to the AIA D101-95 document, and go farther to specify methodology and clarification important to hospital and healthcare projects.

3) The proposed standard should be developed on a consensus basis in conjunction with representatives of the hospital construction industry.

4) The AIA Academy of Architecture for Health is an appropriate organization to promulgate such a consensus standard.

    a. The AIA Academy of Architecture for Health should convene an interdisciplinary group to work in a broad-based consensus model to develop the standard.
    b. The AIA Academy of Architecture for Health and its related Foundation should consider funding additional research to provide a consensus group with current and reliable data on which to base calculation methodology recommendations.

5) Each firm that is significantly involved in hospital and healthcare design should review its use of area calculation methodologies and train its staff to use the common standard developed by the AIA Academy of Architecture for Health.

    a. Firms that use the standard area calculation methodologies should also offer to include their projects in an accessible data base.

6) Further research is needed to provide those who would work to develop a new standard with reliable evidence on which to base their discussion, deliberation, and decisions.

Suggestions for Further Research:

The current study has shown that there is a need for more data and that replication of the study with a larger pool of projects is advisable. The current study also raises a number of additional questions which merit further study. The researchers hope to be able to answer some of them in subsequent studies.

Area Calculation Methods: A future study should collect, compare, and evaluate the numerous methods for calculation of net and gross areas used by practitioners, programmers, consultants, and contractors. It is conceivable that a properly documented and supported study could contribute to consolidation of definitions and methods to the benefit of the entire industry.

Departmental Area Calculations: The current study examines five major departments, and future similar studies could add to the data collected. Data from a larger sample composed of additional projects would increase the reliability of the conclusions associated with these key departments.

Another possible future study could examine other hospital departments in addition to the five major departments of this study. The future study would ideally use similar methodology. Such a study would complete the analysis of the entire hospital.

Building Gross Calculations: The current study gathers no data associated with building gross calculations. A future study could be performed to answer the larger question of area calculations for the full hospital building, going beyond the strictly departmental answers of the current study.

Specialty Area Calculations: A potentially fruitful study might examine the area calculations of specialty facilities, such as those for children's hospitals, heart hospitals, rehabilitation facilities, or other categories.

Relationship of Program of Space Requirements to Designed Area: The current study documents area calculations for major hospital departments without reference to the intended area originally targeted by the space program. Future studies might benefit from comparison between intended and observed results.

Appendix A: Review of Relevant Area Calculation Methods

The literature provides access to a variety of methods for calculating building area. This section will refer to several which may have bearing on a practitioner's choice of methods, and in the future development of a consensus standard for healthcare and hospital projects. It should be noted that none of the most commonly referenced methods are described as uniquely suited to healthcare.

An accurate measurement of square footage by all involved parties should be of paramount importance in the United States because, "Construction cost statistics are generally expressed in terms of cost per unit of area, usually in dollars per square foot. The cost per area system is only relevant if all involved parties are using the same system for computing the area." (O'Leary, www.dcd.com)

When determining the square footages of buildings architects, developers, real estate agents, contractors, and consumers often come up with different numbers. This is because there are a variety of methods commonly used for calculating building areas. The differences between these methods are based on perspective: "Some methods benefit the tenant, and some benefit the landlord." (http://www.bizjournals.com/boston/stories/2004/05/31/focus9.html)

Interestingly, "As a result of the various business and personal interests affected by the method of calculating building area, a number of different standard systems are in use across the country… Governments and code writing agencies have also defined square footage of buildings in various ways."
(O'Leary, www.dcd.com)

Without an accurate measurement of building areas, an accurate quantification of the amount of work to be done is technically impossible. Furthermore, "successful cost management depends on sound estimating skills. Estimating involves two basic steps: quantifying the amount of work to be estimated and applying reasonable unit prices to these quantities." (AIA. The Architect's Handbook of Professional Practice. 2001 ed.: John Wiley and Sons, Inc., 2001, p. 467.)

The AIA Method

"The American Institute of Architects has developed and published a standard method of calculating building areas. This simple two page document is widely used by elements of the construction industry. This generally accepted method for calculating building areas among architects and contractors is described in **AIA Document D101-1995**, "Method of Calculating Areas and Volumes of Buildings." (O'Leary, www.dcd.com)

William B. Tracy, of Building Area Measurement, declares that in fact, AIA Document D101 "is the basis for all of the construction square foot costs cited in publications used by architects and estimators in project building construction costs." He states that "*D101 does a much better job of defining Gross Area than the BOMA Standard."*
(William B. Tracy, www.buildingareameasurement.com/aia.htm)

Unfortunately, the simplicity that makes AIA D101-95 so appealing is also what gives substantial leeway for different practitioners to interpret it in their own way. There is not, however, a body of literature documenting the routine use of AIA D101-95 by practitioners, or the individual interpretations of ambiguous choices not defined by AIA D101-95 by the architects, programmers, consultants, and contractors who are actively using it.

The E1836-01 Method

E1836-01: *Standard Classification for Building Floor Area Measurements For Facility Management:* This standard provides a systematic basis for categorizing how floor area in buildings is measured for certain specified purposes, such as facility management, occupant requirements, space planning, or strategic facility planning.
(http://www.astm.org/cgi-bin/SoftCart.exe/DATABASE.CART/REDLINE_PAGES/E1836.htm?E+mystore)

Elemental (Assemblies and Subsystems) Method

This is "an approach that falls between single-unit rate methods and the extremely detailed quantity survey method. (It) involves measuring basic building systems or elements. This approach subdivides the building into a series of functional subsystems, perhaps using the UNIFORMAT framework, and establishes a cost target for each subsystem." (AIA. The Architect's Handbook, p. 468.)

Functional Area Method

The functional area method is a refinement of the simple area method. Each functional space type included in the project, such as the hospital departments in this study, are priced separately. A cost estimate for a hospital might include different square foot cost factors for its food service department, its surgery suite, the patient units, and administrative space. "This method assumes that the functions performed in the building will have a considerable bearing on its cost – a concept that holds true for interior construction but has less effect on the cost of the basic building shell." (AIA. The Architect's Handbook…, p. 468.)

Office Building Method: The BOMA Standard

The Building Owners and Managers Association have produced widely recognized standards employed in the design of office buildings. "The American National Standard for Measuring Floor Area in Office Buildings (**ANSI Z65.1-1980**), (is) popularly called the BOMA Standard since it and its forerunners have been developed and shepherded by BOMA International…" (Windsor, John H., *A Square Foot is a Square Foot Except When It Is Not*, 1987)

Quantity Survey Method

“This method involves detailed calculation of all the components necessary to construct the building, followed by the pricing of each component. For example, the element method may base plumbing costs on the number of fixtures, including roughing-in and water and waste connections. The quantity survey method measures each fixture separately as well as the length of each piece of pipe and the quantities of the fittings and the trim. It applies price to the materials involved in each construction operation, including allowances for waste, labor (crew sizes and makeup), installation time, equipment used, and for each trade, appropriate allowances for the contractor’s overhead and profit. Although such approaches to estimating are necessary for contractors, they are of limited value to architects. The designer might elect to do a careful quantity survey of alternative approaches for a given design decision or detail but is unlikely to undertake a quantity survey for an entire project.”
(AIA. The Architect's Handbook…, p. 468.)

Appendix B: Glossary of Terms

Area of a Building: "The sum of the areas of the floors of the building, measured from the exterior faces of exterior walls from the centerline of walls separating buildings." (Instruction Sheet for AIA Document D101)

Architectural Area (AA): The addition of exterior covered areas and mechanical spaces to the Gross Area of a project. AA is used for calculating the cost on a square foot bases after a preliminary design is established. (Kumlin, R. (1995). *Architectural programming: creative techniques for design professionals*. New York: McGraw Hill, Inc., pp. 175.)

Assignable Square Feet (ASF) or Assignable Area: The same as net assignable area and net useable area. "Total square footage of area classified as dedicated spaces measured from inside wall to inside wall."
(http://www.facilities.mnscu.edu/cffohandouts/jan02/glossaryTerm.html)

Building Gross Square Feet (BGSF): "…total area occupied by the building measured from exterior to exterior. This area will include all mechanical chases, corridors, elevator/stair wells, mechanical penthouses/rooms, and building skin typically not included in a space program."
(http://ordesignandconstruction.com/glossary.htm)

Circulation Area (CiA) or Floor Circulation Area (FCiA): "The portion of the Gross Area, whether or not enclosed by partitions, that is required for physical access to some subdivision of space… *Basis for Measurement:* From the centerline of the partition, or if the circulation is not enclosed, measurements should be taken from imaginary lines that conform as nearly as possible to the established circulation pattern of the building… Includes corridors (including phantom corridors through large un-partitioned areas), vertical circulation including stairs and stair halls, elevator shafts, escalators, lobbies, and tunnels and bridges for utilization by people…" (Kumlin, (1995), pp. 177.)

"Includes interior corridors, exterior covered walks (1/2 of full area) and phantom corridors, which are undefined circulation areas through assigned areas, such as a pathway through a programmed lobby space. Note that circulation areas are, by far, the largest single component of unassigned space." (Pena, W., Caudill, W., & Focke, J. (1977). *Problem Seeking*. Boston: Cahners Books International, p. 110.)

Common Area: Spaces that serve all the occupants of a particular floor of the entire building. These areas include lobbies, elevator lobbies, restrooms, and mechanical rooms." (www.gelasvegas.com/gepac/resoglos.html)

Common Area Factor (CAF): "The CAF (also called an "Add-on Factor" or "Load") is used to quantify the efficiency of a floor layout, i.e. the relationship between rentable and usable square footage… A building will often quote an average CAF. However, the factor will be different on each multi-tenant floor, based on how the space is divided. The CAF for a single-tenant floor should be much lower because there are fewer corridors, and the bathrooms, etc., are not shared by other tenants. The CAF may include off-floor common areas such as the lobby, loading docks, etc., and tenants are charged based on their pro-rata share of the building." (www.gelasvegas.com/gepac/resoglos.html)

"… calculated as rentable square feet divided by usable square feet. It is used to calculate the total number of square feet for which a tenant will pay rent given the usable area."

(http://www.webs.twsu.edu/longhofer/Common/Real_Estate_Jargon.doc)

Construction Area: (see Gross Building Area) "The portion of the Gross Area that cannot be put to use or otherwise classified because of the presence of structural features of the building." (Kumlin, (1995), pp. 178.)

Departmental Gross Square Feet (DGSF) or Departmental Gross Area (DGA): The space of an entire department, not including the main corridors, stairs, and elevators. The space includes everything in that department including the structural system and small hallways "Gross area occupied by the constituent departments of a building excluding common spaces shared by multiple departments such as common mechanical and circulation spaces. This area will include wall thickness, circulation pathways within the department, and other spaces typically not listed as part of the functional space program for each department." (http://ordesignandconstruction.com/glossary.htm)

"The sum of all net areas within a subgroup and intradepartmental circulation for access to these areas… Basis for measurement: From the centerline of all interior partitions and predominant inside face of exterior wall."
(Kumlin, (1995), pp. 180.)

Efficiency Ratio: "The ratio of net assignable area to the unassignable area expressed as percentages of the gross area. In the programming phase, this ratio is used to project the total gross area requirements using the net area requirements as a base." (Pena et al, 1977, p. 108.) "Differences in predominating room sizes, occupancy levels, circulation requirements and special mechanical requirements lead to different efficiency ratios for various buildings." (Pena et al, 1977, p. 110.)

Floor Area Ratio (FAR): A land use calculation based on the property and the amount of constructed space in the building. "The floor area of a building divided by the area of the lot." (www.cityhpil.com/pdf/cd-definitions.pdf)

Floor Common Area: "…areas common to all the tenants of a floor, such as corridors, elevator lobbies, washrooms, janitor closets, telecommunications and utility areas. Floor common area is often found in and around a building core."
(http://www.xmeasures.com/rm_bomaresource.htm)
(see actual BOMA Standard)

Floor Gross Area: The entire area of an individual floor, measured from the outside face of the exterior wall. It includes every element, including shafts and stairs.

Floor Rentable Area: "…the tenant's pro-rata portion of the entire office floor, excluding elements of the building that penetrate through the floor to areas below. The Rentable Area of a floor is fixed for the life of a building and is not affected by changes in corridor sizes and configuration. The Floor Rentable Area is computed by measuring to the inside finished surface of the dominant portions of the permanent outer building walls, excluding any major vertical penetrations of the floor." (http://www.officefinder.com/boma.htm)
(See Rentable Area)

Gross Rentable Area: "Rent is typically paid based upon the gross rentable area which includes the floor rentable area plus the pro rata share of Building Common Area." (http://www.officefinder.com/boma.htm)

Half Area: AIA D101 describes it as the result of a calculation for exterior canopies, overhangs, and soffits, which is then halved for the purposes of calculating cost on a square foot basis

Load Factor: "The Load Factor, or R/U Ratio, is the percentage of space on a floor that is not usable plus a pro-rata share of the Building Common Area, expressed as a percent of Usable Area. A Typical range is 10% to 18%." (http://www.officefinder.com/boma.htm)

Mechanical Area: "The sum of all areas on all floors of a building designed to house mechanical equipment, utility services, and shafts… *Basis for Measurement:* Measure from the predominant inside face of the outside wall and the centerline of all other partitions." (Kumlin, (1995), pp. 182.)

"Mechanical areas and walls, partitions and structure can each increase to 12% in monumental buildings." (Pena et al, 1977, p. 110.)

Net Area: "…the total of all the primary occupied and functional areas that are required to perform or provide operational support to the prescribed mission of the facility…. Basis for Measurement: For rooms with an exterior wall, *Net Area* is measured from the dominant inside finished surface of the exterior wall (not including interior pilasters or minor projections) to the centerline of the opposite interior partition. All other measurements are to the centerline of the wall that separates the room from the adjoining room or space…. For programming and preliminary design, Net Area (N) is the total of all programmed spaces. Net Area includes assigned and primary functional spaces such as offices, laboratories, conference rooms,…etc… It does not include intra- or interdepartmental circulation, corridors, toilets, stairs, custodial spaces (except for large storage rooms), mechanical and electrical spaces, or service areas. Atria, lobbies, and foyers should be considered net area only to the extent that they exceed the circulation or exiting requirement." (Kumlin, (1995), pp. 173-174.)

Net Assignable Area or Assignable Area: "The total amount of activity space for a project… (But), the net assignable area is not the size of the project." (Cherry, Edith, *Programming for Design: From Theory to Practice*, John Wiley and Sons, Canada, 1999, p. 215)

"…Includes the sum of all functional spaces required to serve the basic program." (Pena, (1977), p. 108.)

Net Square Feet (NSF) also called Net Useable Area: The clear area inside of the space. "…The sum of all areas on all floors of a building assigned for a specific room use, and areas necessary for the general operation (non-assignable area) of a building. Area taken up by the structural building features should not be included in the calculation for Net Useable Area… *Net Useable Area* = Assignable Area + Non-assignable Area (measured from inside wall to inside wall."
(http://www.facilities.mnscu.edu/cffohandouts/jan02/glossaryTerm.html)

Net to Gross Ratio:

$$\frac{\textit{net assignable area}}{\textit{gross area}} = \textit{efficiency ratio}$$

(Cherry, Edith, *Programming for Design: From Theory to Practice*, John Wiley and Sons, Canada, 1999, p. 217)

Non-assignable Area: "…The sum of all areas on all floors of a building not available for assignment to an occupant or for specific use, but necessary for the general operation of a building…" (Kumlin, (1995), pp. 183-184.)

Occupiable Area: "The portion of floor area that can effectively be used for space planning and furniture layout. It does not include the area taken up by primary circulation… columns, perimeter convectors, pilasters, projections, and other building features that would prevent the occupant from effectively placing furniture or equipment… Occupiable area is not a standard definition within the American Society of Testing and Materials (ASTM). Occupiable area and a similar term, effective area, are proceeding through the standardization process within ASTM Subcommittee E06.25 on Whole Buildings and Facilities."
(Blair and Thatcher, http://www.emeraldinsight.com/Insight/)

Rentable Area, Rentable Square Feet (RSF): "Only major vertical penetrations and their enclosing walls are extracted from measurement. These figures do not change unless the building is added to or remodeled so that these penetrations are altered." (Windsor, John H., *A Square Foot is a Square Foot Except When It Is Not*, 1987)

"Determined by adding usable footage to the tenant's proportionate share of the common areas of the building." (www.orgspaces.org)

"In some instances, 1996 BOMA measurements will actually *increase* the amount of common area counted in the rentable square footage…"(www.orgspaces.org)

"Rentable Square Feet is directly related to the amount of common areas in a building and the efficiency of the building. It's equal to the Usable Square Feet plus a tenant's pro-rata share of the building's common areas. Vertical penetrations such as elevator shafts, stairwells, and mechanical shafts are

excluded from the common areas and Rentable Square Feet." (www.gelasvegas.com/gepac/resoglos.html)
(see actual BOMA Standard)

"…is the area for which rent is typically charged and is therefore the number to pay attention to for budgeting purposes. It is the usable area (USF) plus the tenant's percentage share of the building's common areas. For estimating purposes, multiply USF by a factor of 1.16 to get RSF." (http://www.washington.edu/admin/reo/departments/understanding.html)

"…the tenant's usable and it's proportionate share of floor common area and building common area." (http://www.xmeasures.com/rm_bomaresource.htm)

"…Same as *Single Occupant Net Assignable Area*… The space occupied or that could be occupied by the tenant that occupies an entire floor. It includes corridors, utility and mechanical rooms, and public toilets, but excludes major penetrations such as elevator shafts, major mechanical shafts, and stairs. *Basis for Measurement*: Measured to the inside finished surface of the permanent outer building walls, to the face of the walls of major vertical penetrations." (Kumlin, (1995), p. 185-6.)

Tare: "Space for mechanical equipment and walls. Tare could be thought of as the inverse of Net Assignable Area." (Cherry, Edith, *Programming for Design: From Theory to Practice*, John Wiley and Sons, Canada, 1999, p. 215)

"Tare (T)… identifies the gap between gross and net… and is an expansion of a term commonly used to define the weight of the wrapper, container, or waste that is deducted to determine the weight of the goods." (Kumlin, (1995), p. 175.)

"Normally not calculated except as a remainder, it includes all circulation, mechanical, construction, and nonassigned spaces required to support the primary mission net space." (Kumlin, (1995), p. 189.)

Total Rentable Area: "Also known as *gross leasable area* or *rentable square fee*t. This is the area for which rent can be charged, including the tenant's usable area and any common areas for which tenants are charged on a pro rata basis. For the entire building this is the gross measurable area minus any vertical penetrations (e.g., elevator shafts, vents, stairways, etc.). For a given floor this is the gross measured are of the floor minus major vertical penetrations." (http://www.webs.twsu.edu/longhofer/Common/Real_Estate_Jargon.pdf)
(See Rentable Square Feet)

Useable Area, Usable Square Feet (USF): "Simply rentable area less the common area of that floor." (Windsor, John H., *A Square Foot is a Square Foot Except When It Is Not*, 1987)

Utilization: "A measurement used primarily for programming and for the measurement and analysis of the preliminary design related to the program. It is the basis for calculating the efficiency of the building." (Kumlin, (1995), p. 174.)

Volume of a Building: "The sum of the products of the areas, multiplied by the floor-to-floor height or floor-to-mean finished height." (Instruction Sheet for AIA Document D101)

Appendix C: Summary of Judgment calls

Category	Dept.	Location	Judgment Call
Boundary Condition	All	Corridor	8'-0" clear width held consistent throughout department
Shared Corridor	All	Corridor	Shared corridors divided in half, SF given to adjacent departments equally
Structural Columns	All	Internal columns	Included in Department Gross Square Footage
Mechanical Shafts	All	Internal to dept.	Included in Department Gross Square Footage
Exit Stairs	All	Internal to dept.	Excluded from DGSF & DNSF calculations, walls surrounding shaft excluded in DGSF
Elevator Shafts	All	Internal to dept.	Excluded from DGSF and DNSF calculations
Work cores	All	all depts.	ex)Technician Work Core-Imaging: all circulation included in NSF
Nurse Stations	All	internal circulation	Circulation to meds supply station not included in DNSF (circumstantial)
P-tubes	All	Nurse Stations	Pneumatic tube systems not included in DNSF: included in DGSF
Boundary Condition	All	Nurse Stations	NSF to extend to counter edges and exterior of walls defining the space
Nurse work areas	All	Corridors	NSF to extend a maximum of 3'-0" past counter face; will defer to 8'-0" corridor
Open Patient Care Areas	All	Open areas	NSF will defer to the curtain line that defines the space; square-off corners
Entry Condition	ED	Vestibule	Included in DGSF and DNSF
Sub-departments	Surgery	PACU	Included in DGSF and DNSF
Sub-departments	Surgery	Central Sterile	Excluded from DGSF and DNSF
Communication Closets	All	Internal to dept.	Excluded from DGSF & DNSF calculations, walls defining room are divided in half and included in DGSF
Electrical Closets	All	Internal to dept.	Excluded from DGSF and DNSF calculations, walls defining room are divided in half and included in DGSF
Security areas	ED	Internal to dept.	Included in DGSF and DNSF
Equipment alcoves	All	Internal to dept.	Included in DGSF and DNSF: defer to 8-0" clear corridor space
Shell Space	All	Internal to dept.	Included in DGSF + DNSF if room boundaries are clearly defined with future corridor space and walls.
Scrub/hand wash sinks	All	corridors	Included in DGSF and DNSF: defer to 8-0" clear corridor space
Shared spaces	All	multiple depts.	Spaces labeled used by multiple departments DGSF and DNSF equally divided among the two
Nuclear Medicine	Imaging	embedded in dept.	Included
Endoscopy	Surgery	imbedded within dept.	Not included
Emergency	ED	LRMC	Good example for judgment calls
Island Condition	Imaging	Blind 3	Good example for judgment calls IE. Island condition and through corridor.
Shell Space	Surgery	Spring Valley + St Rose	Shell Space included in DGSF + DNSF. Wall thickness excluded from DNSF numbers

Appendix D: Principal Investigators

Faculty participants include David Allison, AIA, ACHA, Professor of Architecture and Director of the Architecture + Health program at Clemson University and D. Kirk Hamilton, FAIA, FACHA, Associate Professor of Architecture and Fellow of the Center for Health Systems & Design at Texas A&M University. They guided the work of the graduate student researchers and collaborated on authorship of the report

David Allison, AIA, ACHA, is a Professor and the Director of Graduate Studies in Architecture + Health at Clemson University, one of only two professional degree programs in the nation with a concentration in Architecture for Health. The A+H program at Clemson is nationally recognized for excellence within the profession. It is focused on preparing architectural graduates to engage in the planning and design of health care facilities, the healthful design of communities, and the healthful design of the built environment in general.

Professor Allison is a registered architect in California, South Carolina, and North Carolina, is NCARB certified, and maintains a limited part-time consulting and architectural practice as time permits. He is a founding member of the American College of Healthcare Architects, serves on the AIA Academy of Architecture for Health Leadership Council, and recently completed a three-year term on the AIA/AAH National Advisory Board.

D. Kirk Hamilton, FAIA, FACHA, is a Fellow and Interim Director of the Center for Health Systems & Design, and Associate Professor of Architecture at Texas A&M University in College Station, Texas, where his research area is the relationship of evidence-based health facility design to measurable organizational performance. He is Founding Principal Emeritus of WHR Architects, Houston and Dallas. WHR (www.whrarchitects.com) is an internationally recognized firm that specializes in healthcare architecture.

A board certified healthcare architect with 30 years experience in hospital design, Hamilton was elevated to the AIA College of Fellows for his advocacy for excellence in architecture for health, innovations in design, for research, and his visions for the hospital of the future.

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Future Studies: Firms interested in contributing materials for later phases of this study should contact adavid@clemson.edu or khamilton@tamu.edu.