## INPATIENT UNIT DESIGN: DEFINING THE DESIGN CHARACTERISTICS OF A SUCCESSFUL ADAPTABLE UNIT

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Healthcare is perhaps going through one of the most challenging phases in U.S. history, with an aging population, rising acuity, growing consumer expectations, a tighter labor market, and advancing technology. Hospitals continuously respond to such changes by implementing changes in unit operational models. The physical design of a unit could facilitate or impede the implementation of such changes, thereby affecting efficiency, stress, and renovation cost. In view of the massive investment being made into inpatient units, this research aimed at ascertaining: 1) what flexibility means to different stakeholders of care delivery, 2) what physical design variables stakeholders identify as dimensions of architecture that influence flexibility, and 3) what elements of the designs promote or hinder flexibility. Existing literature discusses flexibility mostly at the hospital or the patient room level. Moreover, typical flexibility considerations have centered on convertibility and expandability. This study makes a contribution to understanding flexibility at the inpatient unit level, from a viewpoint of adaptability to operational changes. The study used an exploratory design and collected data through semi-structured interviews of stakeholders in nursing, materials management, respiratory services, pharmacy, environmental services and dietary services from six hospitals across the United States. Content analysis of interview transcript suggests a set of seven 'static' attributes the presence of which, irrespective of size, shape, circulation, and other configurations, would ensure flexibility of operations in the short as well as long run: 1) multiple division/zoning options, 2) peer lines of sight, 3) patient visibility, 4) centrality of support, 5) resilience to move/ relocate/interchange units, 6) multiple administrative control and unit spread options, and 7) ease of movement between units and departments.

# Inpatient Unit Design:
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# I. Introduction

## 1.1 Contents and definitions

This document reports the findings of a study that attempted to articulate the notion of flexibility in inpatient care, and to identify attributes and elements of the physical environment that facilitate or impede flexibility during the useful life of a unit design. A portion of the data deals with aspects of the designed environment that worked very well or need more thought to appropriately support unit functional needs. This document, however, does not constitute a Post-Occupancy Evaluation (POE) of the facilities studied, and should not be treated as one. More importantly, the discussions should not be viewed as a criticism of the unit designs since many non-physical factors such as operational concepts, models of care, and user perceptions constitute a substantial component of this complex evaluation.

During the progress of the study it was quickly realized by the authors that frequently used terms in healthcare design and clinical practice may not have commonly understood definitions. For the purpose of this study we will use the definitions outlined in Table 1 throughout this document. It is appreciated that the audience may have a different definition of the terms used. It is hoped that any differences in opinion or definitions among healthcare designers, researchers and/or clinical professionals will lead to a constructive dialogue towards developing a commonly understood set of terminology and measures to enhance research efforts on this important topical area.

| Terms | Definitions |
|---|---|
| Nursing Care Model or Nursing Model of Care | The organizational construct for nursing care, involving registered nurses, licensed practical nurses, and certified nurse assistants / patient care technicians that is adopted to provide and optimize patient care; examples are Primary Nursing, Team Nursing, Functional Nursing, etc. |
| Care Delivery Model or Model of Care Delivery | A holistic patient care delivery design which situates nursing care within a larger framework that includes personnel from support service departments such as environmental services, materials management, pharmacy, respiratory therapy, dietary services, and other functions that are integral to care of patients. |
| Adult Medical-Surgical Unit | Patient populations admitted to the unit are either surgical post-operative patients or stable medical patients with acute medical complications. (as opposed to an unstable population in Intensive Care.)<br>Units could include subspecialty assignments such as gastroenterology, orthopedics, cardiac care, oncology, neurology, and pulmonary. Medical units could also include telemetry or step-down units as these units are typically not different in physical design from typical medical / surgical units. |
| Universal Patient Room | An inpatient room intended to accommodate patients at all levels of acuity. The concept is intended to eliminate the need for transferring or "stepping-down" patients to multiple rooms and/or units during their stay in the hospital from admission to discharge. It is standardized in shape, size, and headwall equipment (monitoring and communications technology mounted onto the wall at the head of the patient's bed) to eliminate the need to move patients as their condition changes.<br>This room is often referred to as an "acuity-adaptable room", as coined by Hendrich (2004) [11]. However, there is some inconsistency within architectural community in the use of this term to include rooms designed sufficiently large, with outboard toilets and "soft" corridor walls, essentially pre-planned for "light" renovation to provide larger viewing windows and additional utility outlets. This concept is aimed at saving initial cost while providing the option to relatively easily modify the room to truly handle all acuity levels. Hamilton (2000) has more accurately labeled these types of rooms as having "convertible flexibility" [17].<br>This study draws a specific distinction that "acuity adaptability" should be applied to unit discussions (and not patient room labels), as in an acuity adaptable unit, and that patient rooms equipped at the outset to accommodate all levels of patient acuity should be referred to as universal rooms, not acuity adaptable rooms, in order to eliminate this confusion in architectural concepts. |
| Variable-Acuity Nursing Model | A nursing model of care designed to serve a patient population at all levels of acuity from acute care to step-down to intensive care. This model of care requires universal rooms, and more importantly, a significantly different deployment of trained critical care resources or a general nursing workflow that is more highly trained across the board. |
| Acuity-Adaptable Unit | An inpatient unit designed to accommodate patients at all levels of acuity (through provision of 100% universal patient rooms). This terminology may also be used for units that are designed with rooms that can be easily modified in the future to support a variable-acuity nursing model with minimal time and renovation. (See Universal Room definition). |
| Acute Care Room | An inpatient room designed for the acuity level of a typical medical / surgical patient. |
| Standardized Room | An inpatient room design intended to be replicated with consistent, identical elements of caregiver support and family amenities, such as work surfaces, support storage, equipment, medical gases, sinks, and so forth. Such rooms could fit the category of Universal Patient Room or Acute Care Room. |
| Standardized Unit | An inpatient unit that is designed with the same configuration - patient room size, support core elements and circulation, and repetitively applied to accommodate the majority of medical-surgical patient room needs of a hospital. |
| (Nursing) Staffing | Assignment of nursing staff (in a particular care delivery model) to patients. |
| (Nursing) Teaming | A (Nursing) staffing assignment designed to accommodate team efforts in patient care. |
| Caregiver Team or Multi-disciplinary Team | A team comprised of staff from nursing, pharmacy, respiratory therapy, environmental services, materials management, dietary services, and other services, that together, provide patient care. |
| Unit Size | The total number of beds in a unit (presumably patient rooms as well, assuming all private rooms). |
| Unit Area | The size of floor plate of a unit in square feet. |
| Unit Shape | The overall shape/ configuration of rooms layout in a unit, such as square, circle, rectangular, triangular, etc. |
| Unit Circulation | The circulation design in a unit vis-à-vis unit shape and support areas, such as single-loaded, double-loaded, race-track, etc. |
| (Nursing) Pods | A configuration where a small number of patient rooms (i.e., a subset of patient rooms within a unit) are provided with their own nursing and support area within a larger unit. |
| Support Core | The spaces on a unit that support the needs of the caregivers. Such spaces could include nursing station, clean utility and soiled utility rooms, medication rooms, nourishment rooms, housekeeping closets, mechanical rooms, staff rooms, and rooms to support interdepartmental interactions. |
| Peer Line of Sight | Line of sight between caregivers at work on a unit. |
| Patient Visibility | Maintaining visual and /or auditory contact with patients. |

*Table 1*. Definitions of healthcare terms used in this document

## 1.2 Healthcare trends contributing to the importance of enhancing flexibility through design.

Healthcare is perhaps going through one of the most challenging phases in United States history. The aging of the American population [1] the rising acuity level in inpatient care [2], the gradual shift towards more chronic conditions [3], and growing expectations of healthcare consumers constitute one set of challenges. A labor market that is witnessing an upward trend in nursing staff age along with current and projected shortage in nursing staff [4], staff dissatisfaction with prevailing work environment, and high turnover of nursing staff [5], pose a separate set of challenges. Rapid development in information technology (such as electronic medical record system-EMR, computerized physician order/entry system-CPOE, and supply and medication bar coding systems), and technological advances in diagnosis, imaging and other crucial areas of care delivery are beginning to change the way patient care delivery is conducted. Patient safety issues have recently emerged as a major concern, resulting from two significant reports from the Institute of Medicine [6]. High rates of medical errors, hospital acquired infections and other factors are affecting operating costs as well as community perception of healthcare facilities. Coupled with the above challenges the healthcare industry is facing the prospect of long-term financial un-sustainability. A study of financial and operational data of 750 healthcare organizations shows that since the Balanced Budget Act of 1997, operating costs have reduced operating margins to uncomfortable limits [7]. More specifically, the aforementioned survey points to the fact that average operating margin in 2004, at 4.04%, presents a potential long-term risk for the operation of hospitals. That compares to a minimum 4.5% (and suggested 5.5%) as recommended by industrial analysts [8]. In addition to the above challenges, communities are expecting more responsible hospital design – designs that are sustainable and environment friendly in the immediate as well as the long run.

## 1.3 The role of flexibility

Hospitals continually respond to such changes in internal and external factors by implementing changes in unit operational models [9]. The physical design of a setting either facilitates or impedes the implementation of such changes over the life of a hospital. Designs that impede changes can lead to expensive renovation work during the life of a facility, premature obsolesce of a facility, or, all too often, development of care-giving plan that is sub-optimal because it is adapted to the facility constraints.

The physical design of facilities can influence staff effectiveness [10]. Depending on the degree of adaptability a facility permits, the period between making operational changes and conducting physical renovations in response to those changes could witness significant reduction in staff efficiency and an increase in work-related stress. From the viewpoints of efficiency, staff well-being and lifecycle cost, it is essential that the built environment be rendered adaptable to different unit operational models over a facility's lifetime.

## 1.4 Views on and attempts at infusing flexibility

While flexibility in healthcare has been widely addressed, a major focus in professional literature over the past decade has been at the scale of the entire hospital or the individual patient room. Demand for overall flexibility due to future expansion needs, changes in technology and clinical practice, and modular systems and furnishings constitute typical subject matter of discussion [11]. Flexibility of the hospital building has also been considered in a concept termed 'open building', suggesting that flexibility is built into design by fragmenting the design into three systems based on service life: 1) primary system (nearly 100 years), 2) secondary system (nearly 20 years), and 3) tertiary system (nearly 5 to 10 years) [12]. Drawing some parallel to design and procurement of retail and office buildings, the separation of the systems ensures independence of the lower-level systems from the higher level systems, affording flexibility to changes while minimizing construction.

At the patient room level, the majority of literature have centered on universal rooms and the variable acuity nursing model. Originating with the desire to improve patient satisfaction and reduce patient transfers between units corresponding to changes in acuity level over time, the intention was to reduce costs associated with patient injury, staff injury, medical errors arising from clinician hand offs, among others [13]. Universal rooms have gained popularity ever since, owing to the assertion that they enable flexibility in patient allocation [14], staffing, and long-term adaptability of units to changes in patient population, acuity and census [15]. Universal rooms, however, require larger floor areas and require better visibility, which partly drove the decentralization of nursing and support spaces, with support from advances in information technology that promised radically different ways of inputting and accessing information [16].

The above notions of flexibility can be viewed as 'adaptable', 'convertible' or 'expandable' attributes of the physical environment. The terms adaptable and convertible flexibility were coined by Kirk Hamilton in the context of critical care design [17]. Adaptable flexibility is the "ability to accommodate changing conditions without any change in the environment," and convertible flexibility is the "ability to accommodate a change after a simple and/or inexpensive physical alteration." ([17], page 476). Expandable flexibility can be summarized as the ability to expand or contract a space to accommodate a particular function, as in future expansions. Universal rooms constitute one instance of adaptable design. The discussions by Chefurka et al (2006), Varawalla (2004), and Reddington et al (2004) deal more in the areas of convertibility and expandability.

## 2. Problem Statement and Research Objective

### 2.1 Problem statement

Despite considerable discussions on flexibility in professional literature, empirical research on flexibility of inpatient units is not widely published. Moreover, it would not be erroneous to contend that understanding of flexibility has an architectural bias centering on convertibility and expandability. This study was founded on the realization that the meaning of flexibility from different stakeholders' perspective at the inpatient unit level is currently not well understood. As a result, design ideas aimed at promoting flexibility – one example being universal rooms - are randomly being incorporated into designs. These ideas have been based on untested hypotheses, applying the assumption that the concept would accommodate necessary adaptation for appropriate care delivery in the long run.

Such experiments are expensive and may or may not produce intended support to changes in operational models. Moreover, most of the attempts at rendering adaptability have focused primarily on the definitions of staffing (nursing) flexibility. However, nursing staff interact with a host of other services while performing their duties including, among others, food services, environmental services, respiratory therapy, facilities/ plant management, patient transport, security, materials management, biomedical services and pharmacy [18]. Arguably, flexibility in nursing care delivery does not occur in isolation of flexibility needs of the support services. Knowledge on the meaning of flexibility and adaptability needs, from the viewpoint of all stakeholders of the care delivery process, would help address the critical needs related to nursing efficiency and facility obsolesce. From a facility design viewpoint, identification of the characteristics that bear maximum influence on flexibility would help stakeholders focus on the most potent areas during inpatient care unit design.

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## 2.2 Research Objective and Question

This research is intended to inform decision-making in the design of inpatient care units that will maximize flexibility for implementing changing unit operational models while minimizing physical design change/redesign costs, improving or maintaining efficiency over time, and lengthening economic life of inpatient care units. Toward that objective, this research focused on the following questions: 1) What does flexibility mean to different stakeholders of care delivery in hospital inpatient care units, and 2) What physical design variables do stakeholders identify as the critical dimensions of inpatient care unit architecture that influence their flexibility? 3) What elements of the designs of inpatient care units promote or hinder unit flexibility?

## 2.3 Scope of Research

Flexibility in healthcare design is a vast topic. This study focuses on adult medical-surgical inpatient units, which typically comprise 25-30% of physical area and capital cost in healthcare facilities (the aggregate area of inpatient care is usually over 40% of a typical hospital area and construction budget.) Study of this specific hospital component is important as it currently constitutes the vast majority of hospital expansion programs to respond to the rapidly changing demographics and healthcare demands in the U.S. Further, adult medical-surgical units are the most common inpatient units across all hospital types – rural, suburban and urban hospitals as well as in general hospitals and centers of excellence. Choosing this inpatient unit type was intended to enhance wider applicability of study findings.

| NAME | LOCATION | CONSTRUCTION COMPLETION | TOTAL INPATIENT BEDS | SQUARE FOOT PER BED | UNIT SIZE | UNIT SHAPE | CIRCULATION | NURSING MODEL | PATIENT NURSE RATIO | UNIVERSAL ROOM |
|---|---|---|---|---|---|---|---|---|---|---|
| Parker Adventist Hospital | Parker, Colorado | 2004 | 100 licensed beds | 607 | 36 | Irregular | Racetrack | Primary Nursing | 1:5 | Yes |
| Clarian West Medical Center | Avon, Indiana | 2005 | 76 beds | 700 | 32 | Square | Racetrack | Primary Nursing | 1:4 | Yes |
| Laredo Medical Center | Laredo, Texas | 1998 | 325 licensed beds | 528 | 36 | Pinwheel | Racetrack | Functional/ Modular Nursing | 1:8 | No |
| McKay-Dee Hospital Center | Ogden, Utah | 2002 | 317 | 673 | 28 | Triangle/ Rectangle | Racetrack | Functional Nursing | 1:5 | No |
| Bon Secours St.Francis Hospital | Charleston, South Carolina | 1997 | 141 | 520 | 40 | Square | Radial | Modified Team Modular Nursing | 1:5 | No |
| St. Rose Dominican Hospital - Siena Campus | Henderson, Nevada | 1999 | 214 | 541 | 34 | Other | T-Shape | Functional Nursing | 1:6 | No |

Table 2. Attributes of hospitals and inpatient units used in the study

## 2.4 Research Significance

This study assumes significance considering the current massive investments in healthcare facilities, with conservative estimates pegging annual investments at $16-$20 billion over the next decade [19]. With over 45 million square feet of new healthcare facilities construction in place [20], the outcome of this research is expected to make a significant contribution to healthcare decision-making in the United States. Moreover, as elucidated earlier, staff stress as well as operating efficiency and safety, satisfaction and retention are vital areas in decision making today. The study is expected to address these areas by articulating flexibility needs of care giving staff to designers and by addressing ways to enhance supportiveness of the physical environment to functional needs of caregivers over the long run.

## 3. Research Method and Design

The authors conducted in-depth, semi-structured interviews with the management, nursing and support staff at six not-for-profit hospitals across the United States to understand their interpretations of flexibility and attributes of physical design in adult medical-surgical units that facilitate or impede flexibility. All six hospitals are new construction, completed in the past decade, and designed by HKS, Inc. Limiting the study to HKS-designed hospitals was intended to reduce logistic problems associated with organizing site visits, soliciting respondents, conducting interviews, and analyzing data within the study timeframe. The hospitals were selected through a purposive sampling of all hospitals designed by HKS, Inc. to maximize variations in physical attributes including unit size, unit shape, circulation type, and location. Table 2 outlines the key attributes of the hospitals included in the study. Table 3 describes charting and data access at the units included in the study.

| NAME | PRINCIPLE CHARTING LOCATION | INTENDED CHARTING AREA DURING DESIGN | ELECTRONIC | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | NURSE CHARTING | PHYSICIAN CHARTING | MULTI-DISCIPLINARY CHARTING | PHYSICIAN ORDER ENTRY | PACS | ELECTRONIC LABORATORY RESULTS |
| Parker Adventist Hospital | Sub-stations | Sub-stations | No | No | No | No | Yes | Yes |
| Clarian West Medical Center | Room-side | Room-side/ Sub-stations | Yes | Yes | Yes | Yes | Yes | Yes |
| Laredo Medical Center | Sub-stations | Room-side/ Sub-stations | No | No | No | No | Yes | Yes |
| McKay-Dee Hospital Center | Sub-stations | Room-side/ Sub-stations | Yes | No | No | No | Yes | Yes |
| Bon Secours St. Francis Hospital | Sub-stations | Sub-stations | Yes | No | Yes | No | Yes | Yes |
| St. Rose Dominican Hospital - Siena Campus | Sub-stations/ Room-side | Room-side/ Sub-stations | No | No | No | No | Yes | Yes |

Table 3. Charting and Data Access in the Study Sample

At each hospital, participation was solicited from selected stakeholders in patient care services (Chief Nursing Officer, Department Director, Department Manager, Charge Nurses and Staff Nurses) and services that support nursing care delivery including respiratory therapy, dietary services, environmental services, materials management, and pharmacy. The volunteering participants were interviewed individually for one hour by two research team members on site. Interviews were guided by a plan of inquiry (see Figure 1) prepared and tested before the site visits.

The plan of inquiry included questions that addressed six main areas: 1) description of a typical day on the unit by the care giving staff, 2) challenges the care giving staffs face in conducting their tasks efficiently, 3) things that contribute to operating efficiency and those that the interviewee would like to change to improve efficiency, 4) areas on the unit that have been changed since occupancy, 5) reflections on how things might change in the future and aspects of the physical design that will need to be changed, and 6) the respondent's interpretation of the term flexibility. The plan of inquiry was pre-tested using a combination of field-testing and cognitive pre-testing methods propounded by Krosnick (1999) [21]. Respondents solicited for pre-testing included people in the areas of nursing, environmental services, and materials management (a list of participants involved in pre-testing is included in the Acknowledgment section of this document.) The plan of inquiry went through sequential modifications after each pre-testing interview. Interviews at the six hospitals were conducted between late September and early November 2006.

**Interview Plan of Inquiry**
Basic Question Set

1. What is the mission / objective of the service you provide?

2. Tell us about a day's events for one of your employees on medical/surgical unit?
    a. What challenges do they experience on a daily basis?
    b. What contributes to the efficiency of their job?
    c. What contributes to the quality of their job?
    d. Who are some of the other people or departments with whom they interface?

3. Have there been changes to the staffing of your department? (ratio or model of care)
    a. What has influenced this change? (Administration, government, new model)
4. What is the ideal situation for their work?

5. What would you do if you could change things?

6. What type of staff injuries occur as a result of their work?
    a. What would improve their safety?

7. What does flexibility mean to you?

In addition to above questions, ask the CNO / Nursing Director / Nurse Manager:

1. What is your current nursing model? Is this the same as your care delivery model?

2. What is your ideal nursing model? Care delivery model?

3. What changes would you make on the unit to support that ideal model?

*Figure 1.* Interview Plan of Inquiry

All interviews were tape-recorded for accuracy and transcribed verbatim for subsequent analyses. Interview transcript were subjected to content analyses with three main objectives: 1) to identify varying interpretations of the term 'flexibility', 2) to understand the relationships between their interpretation of flexibility and their descriptions of functional efficiencies, and 3) to identify attributes of the physical environment that facilitates or impedes functional efficiencies. Data analyses followed the steps suggested by Miles and Huberman (1994) [22]. Text chunks from the interview transcripts were encoded and organized in several stages of data analyses to capture recurring constructs, domains and interpretations.

Brief facility tours, photography, and annotations on floor plans were also conducted to aid in the process of understanding, interpreting and articulating the interviewees' perspective. All interviews were conducted by the same team of two HKS personnel – a registered nurse and doctorate-level architect. The interviewers had considerable prior experience in conducting interviews in exploratory studies. In addition, the team used the pre-testing phases as a maturation phase for subsequent data collection. It is, hence, assumed that internal invalidity arising from maturation or training [23] did not pose any major problem. Further, to enhance validity, copies of the completed report were provided to all interviewees to check for misinterpretations and inaccuracies.

## 4. Findings

If direct patient care seems to be a complex phenomenon, it pales in comparison to the degree and level of interdepartmental coordination that is required in the background to support direct care. To articulate the collaborations and coordination, a hypothetical example will serve the purpose.

A nurse clocks in at 7:00am on a typical day shift, collects her assignment and report, and proceeds to assess her assigned patients. Subsequently, after checking the patient's charts, she proceeds to fetch medications for the patient. She could obtain patient-specific medications from a locked cabinet in the patient room, a nurse server in the patient room or hallway outside the door, or the assigned, centralized automated medication-dispenser (AMD), in which case she may have to wait for her turn to access the machine. That entirely depends on the operational planning and staffing availability in the pharmacy department. This hypothetical patient could have a patient-specific medication that is not available in an AMD. Depending on the nature of medication and staff availability the pharmacy could use the pneumatic tube system or a courier to deliver the medication. In the case of the pneumatic tube, the medication could remain in the receiver or be taken to the medication room or the patient room, hence the nurse could spend time looking in three different locations for one medication. On the other hand, a courier could deliver the medication (in this hypothetical unit) to the nursing station, the AMD, a locked cabinet in the patient room, or in the nurse server – resulting in a search procedure.

The patient room will typically need a fresh set of linen and a thorough cleaning for the day. Linens can be stocked in a nurse server, a portable cart, or in a central linen room; again depending on staffing and the operational model. While patients are checked for vital signs, medications administered, and linens changed, the room will need cleaning to maintain a healthy environment. The EVS tech (environmental services technician) assigned to the unit would already have proceeded through a process roughly parallel to the nurse's schedule, with some exceptions. They would collect their necessary chemical and paper products from the central supply, or such products (including mops) could be delivered to their storage area on the unit, once again depending on the staffing and operations planning of the environmental services department. The conscientious EVS tech starts at the public areas, proceeds to the public restrooms and nursing stations, and finally to the patient rooms. Several times while performing assigned tasks the EVS person receives calls laced with urgency – help needed on another unit, a room needing turnover for a new patient, etc.

Meanwhile, the physician rounding the patients is busy inputting data on a paper chart (easy when traditional) or on a physician order entry system (new and challenging). The physician could use the help of a pharmacist to decide on the right medication. The pharmacist could be available on the floor if operational planning and staff availability permits. Moreover, how would one know whether the pharmacist is on the floor? In addition, breakfasts are being served while the team in charge of patient transport arrives to take the patient for a stat x-ray, and the respiratory therapist arrives to administer the morning treatment before the breakfast arrives. The manner of serving and the involvement of the nursing staff depend partly on the model of dietary service. Are patients served through a 'tray-cart' system, a 'room service' model, or a variety of other models? Who is in charge of serving? Who is in charge of disposing the used trays? Depending on rules established in individual hospitals, visitors and family members of patients are also active during these periods in various ways.

Several other events are in progress as these activities happen. Medications are not the only things that nurses need for patients. Other clean clinical supplies are vital to patient care that could be provided at the nurse servers, clean supply or utility rooms, or on carts; once again based on the operational model and staffing of the materials management department. While these activities proceed, a considerable amount of trash is generated, including trash that could be hazardous. Trash removal is entirely dependent on the diligence, motivation and capability of the personnel of the environmental services and the spatial provision made on the unit.

Typically, patient care conjures the vision of a singular nurse and a physician attending to the needs of a patient in a single inpatient care unit. However, behind this scene are many allied caregivers and support team members that typical have a role serving multiple units in a hospital. Materials management, environmental services, pharmacy, respiratory therapy, and some nursing unit managers (3 out of the 6 hospitals had managers cross covering other units) are examples of caregivers or support staff that deal with multiple units on multiple floors on a regular basis. Close coordination between these caregivers and the direct care staff remains a key to optimum patient care. Such coordination is frequently mired with challenges arising from the customer - patients and families, in addition to potential facility design constraints. A cold meal could result in a negative assessment of care giving. Inappropriate access to patient information could lead families as well as patients to an enhanced level of stress and anxiety, and delayed treatment. And all of these could occur simultaneously with a myriad of accidents that care-givers are continuously exposed to: slips, back injury, burnout, etc.

As will be discussed later, while some impediments to flexibility arise from operational and organizational factors, the role of the physical environment can be viewed through a particular interpretation of flexibility that is most frequent among care giving staff. To arrive at that understanding, however, it is essential that the key operational challenges faced by caregivers be articulated.

## 4.1 Challenges faced by management

Optimizing staffing constitutes a major component of departmental operations in both nursing and support services. While a fair and balanced allocation of responsibilities remains at the heart of staffing, one of the fundamental objectives focuses on teams. Teaming can be looked at from two perspectives. While, generally, nurses are assigned to a group of patients to whom they are primarily responsible to provide all types of care, many situations in the care-giving process demand helping hands. Teaming nurses help optimize care during such situations, which are frequent owing to the uncertainties that characterize the healthcare environment. Teaming nurses have more than just instrumental functions. Teaming helps develop social networks, mentoring and stress mitigation in the work environment typically riddled with operational and environmental stressors. Teaming, however, has a wider connotation than ascertaining physical proximity of nursing staff. As described earlier, nurses are supported by other departments in a hospital. Teaming nurses with support personnel (such as environmental services) helps enhance coordination, improve job satisfaction among support staff and develop a sense of ownership in personnel that are not generally perceived as contributing to direct care.

Yet another problem associated with physical design faced by management is dealing with uncertainties. The most exemplary case of uncertainty is a sudden, unexpected and sustained increase in census, thus leading to the resizing of a service. Since uncertainties affect the match between expectations and reality, it could lead to significant impact on job satisfaction and performance. A case in point is the unit at McKay Dee Hospital Center considered in this study. When the service had 28 beds the hospital experienced little nursing vacancy. Increasing the service size to 44 beds (covering two physical units) owing to an unanticipated change in census led to a sudden spike in nursing turnover rate. Apparently, as opposed to smaller units, census fluctuations in large units could exert unexpected pressure on available staff. In smaller units, it is easier to soak additional population with available staff without a significant increase in workload. Moreover, the possibility of a highly fluctuating workload could, by itself, lead to anxiety and stress in nursing staff.

## 4.2 Challenges faced by direct caregivers

Direct caregivers, specifically nursing staff, experience a set of challenges not entirely unrelated to the ones faced by management. Clear line of sight with other nurses (of the same team or other teams) is essential according to caregivers at all six study hospitals. It offers the perception of availability of support if the situation demands. It offers the opportunity for socialization and peer support, could be instrumental in enhancing mentoring among peers, and could influence the perception of workload. A simple example of workload perception is when non-visibility of peers leads a worker to sense that she or he is engaged in a disproportionate amount of work. Such factors could affect job satisfaction and stress.

Patient visibility is the second crucial factor for effective and efficient care. It is conventionally believed that direct patient visibility is important only in intensive care environments. However, the rise in acuity level of today's medical-surgical inpatient population, as well as increasing efforts to reduce accidents and the risk of falls, has resulted in an imperative for the nurse to have improved visibility and auditory connection with the patient room. This includes greater visibility of the patient from the corridor. The ability to, at a minimum, see the patient room door from the main or sub-workstation provides the nurse with the proximity to hear activity in the room as well as see the patient room door which serves as a reminder to check the patient. Patient visibility essentially entails the ability for visual and auditory monitoring of patient rooms.

Access to materials constitutes another challenge to caregivers. Ideally, nurses prefer to make as few trips as possible to collect supplies and medications. However, problems occur when supplies are spread across several small rooms owing to paucity of space in any single room (healthcare design building codes have sometimes mandated these separations.) That necessitates trips to multiple destinations for collecting supplies. Similarly, some medications are stored in automated dispensing machines while others in refrigerators, which may or may not be located in the same medication room. The cost of this equipment often drives more centralized location of medications than is ideal from a care-giver support perspective.

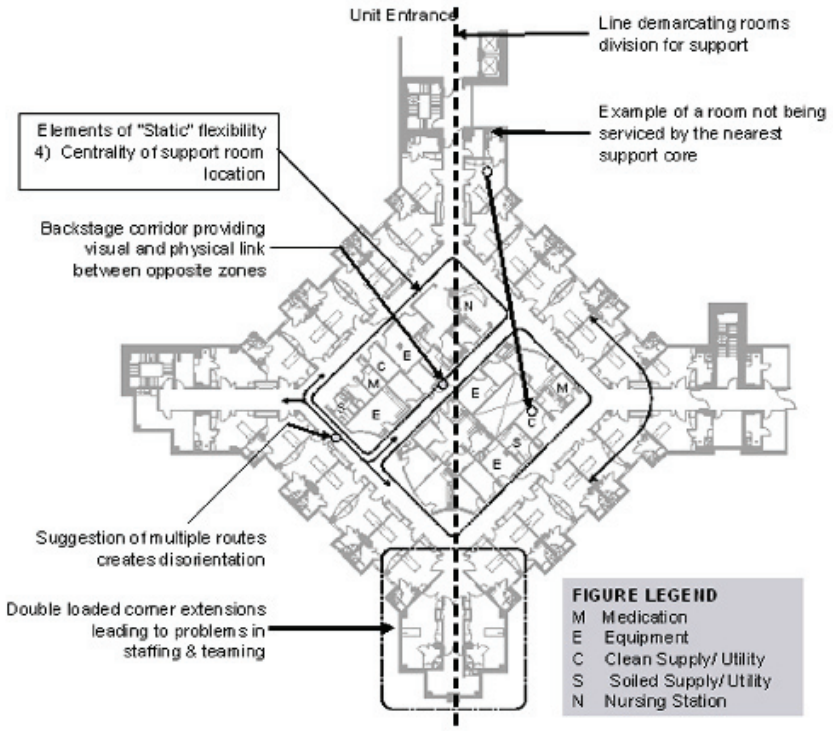


*Figure 2.* Medical-surgical unit at Clarian West Medical Center, Avon, Indiana

Supply storage and automated medication dispensing machines, when distributed on the floor, create a different set of challenges. Typically, a unit is geographically divided into groups of patient rooms to be served out of specific distributed support rooms. The way patient rooms are divided or zoned for staff assignment could lead to situations where a particular patient room is serviced by a support space located farther away as opposed to the nearest available one (observed at two sites). Figure 2 articulates the issue using Clarian West Medical Center as an example. The problem appears to originate from a mismatch between the designer's assumed axis for unit sub-division and the actual axis used for support room allocation. As illustrated in the figure, some rooms are allocated support rooms that are not the nearest available ones. To complicate matters further, zoning for support services could conflict with patient assignment resulting in a nurse visiting different core support zones for different patients. In essence, design of the support core influences walking distances considerably. In addition, lack of centrality of the support core in relation to room assignments (whether centralized or distributed) could aggravate problems associated with movement of materials within the unit.

Another set of challenges for non-nurse care-givers as well as support service staff relates to responsibilities that span across multiple units. These personnel include nurse managers, respiratory therapists, pharmacists, environmental service staff (cleaning, linen, trash), dieticians and materials management staff, to name a few. One perceived impediment to operations lies in the large travel distances that are involved in the regular tasks of such personnel. For instance, a nurse manager assigned to two vertically stacked units often makes long trips from the first unit to the second via stairs or elevator lobbies. This could happen several times during the day. Inter-unit activities and responsibilities create problems when direct (same level) access is not available between some units or when access to one unit necessitates travel through another unit.

How do these challenges relate to or influence flexibility? A review of the various stakeholders' definition of flexibility would help articulate the above discussions in an interpretable framework.

## 4.3 What is the meaning of flexibility?

While different stakeholders had different notions and definitions of flexibility, the following paragraphs are an attempt at summarizing the notions. To the question "what does flexibility mean to you for conducting your work efficiently in the short as well as long run", in general, most responses focused on being able to provide optimum service to the patients, or to the direct caregivers who take care of patients.

For nursing management personnel (CNOs, nurse directors and managers,) flexibility means the ability to change staffing allocation and teaming on demand to address new circumstances, both short–term and long-term. For nursing staff (direct caregivers,) flexibility means the ability to address unique situations and demands, to optimize patient care, to be able to multi-task for maximizing efficiency, and to possess expertise to be able to address different needs (multi-skill). For respiratory therapy, pharmacy, materials management, environmental services and dietary services, flexibility means to be able to change allocation in resources, to be able to cope within available resources, and to be able to handle different kinds of assignments and demands in the larger goal of optimizing patient care.

Allusion to the physical environment as a part of the flexibility definition was minimal. One exception was a response from a pharmacy director who felt that the units should be designed to accommodate known projected advances or availability in technology for distribution of medications, such as pneumatic tube stations in every room (accommodating pneumatic tube system in each patient room was also raised by a senior nursing administrator).

Does the absence of any reference to the physical design by the respondents mean that the physical design has little to do with flexibility? On the contrary, it needs to be viewed from a notion of flexibility that is rarely regarded as a flexibility issue in architectural literature. The absence of reference to the physical environment does not mean that the individual and operational/ organizational attributes desired by the respondents are achievable independent of the attributes of the physical environment. In fact, the physical environment could play a decisive role in facilitating the individual/operational/ organizational attributes yearned for by caregivers. That, in turn, necessitates a deeper inquiry into the responses of the interviewees, to search for clues in their descriptions of needs, challenges, efficiencies and ideal situations. Physical changes effected on units after their initial construction constitute a potential source of information.

*Figure 3.* Overcrowded equipment room at Parker Adventist

## 4.4 Changes on medical-surgical units

Based on interview data, four kinds of major changes have been effected on the units studied since initial occupation: 1) changes to the support core, 2) changes to service size, 3) moving patient population across floors/ units, and 4) changes to nurse stations.

Unit support cores have undergone the greatest change in all units visited in the study. Such changes include change in room functions from those originally assigned. The most frequent change is associated with perceived lack of storage space. Storage-related problems include: 1) insufficient space in storage rooms, 2) inefficient shelves and cabinets, 3) improper widths of rooms, 4) inappropriate room shapes, and 5) inappropriate room location. Among other possible reasons, insufficient storage spaces have, in many instances, resulted from changes in operations post-occupancy, emerging needs for new and additional equipment.

*Figure 4.* Built-in cabinetry incompatible with emerging needs at St. Francis Hospital. While the photograph suggests a neatly arranged cabinet, shutters were removed to accommodate larger packages and lack of vertical separators lead to inefficient searches.

Figure 5. Narrow rooms with dispensing units lead to inefficiency in medication rooms

For instance, in one case a decision was made at a very late phase of facility procurement to decentralize a portion of the respiratory therapy service onto an inpatient care unit/floor. This change necessitated the insertion of a supply room for respiratory therapists as well as an equipment room into the plan. Carving these spaces out of the service core resulted in proportional reductions in other rooms in the core area. In another instance, pre-occupancy planning considered an I.V. pump in each room; however, this was not implemented at occupation. That necessitated a storage space for I.V. pumps not initially considered in the unit design. On all units the requirement for bed storage emerged as a key issue in throughput, thus creating new needs for storage. Figure 3 exemplifies the space crunch typical in most hospitals.

Further, at two hospitals, changes in supply packaging over time led to incompatibility between supplies and built-in shelving/cabinetry provided in storage rooms (Figure 4). In addition, need for vertical separation in shelving and cabinetry changed over time (sometimes frequently) and resulted in inefficient, underutilized storage. Further, at three hospitals, sizes of dispensing systems or other equipment led to a misfit between room size/width and circulation needs within the rooms (Figure 5). In many cases, changes needed in room sizes and dimensions were small (inches), but still un-workable. As a result, support cores regularly undergo room use reassignment (done most often due to cost of construction) renovations to better utilize space.

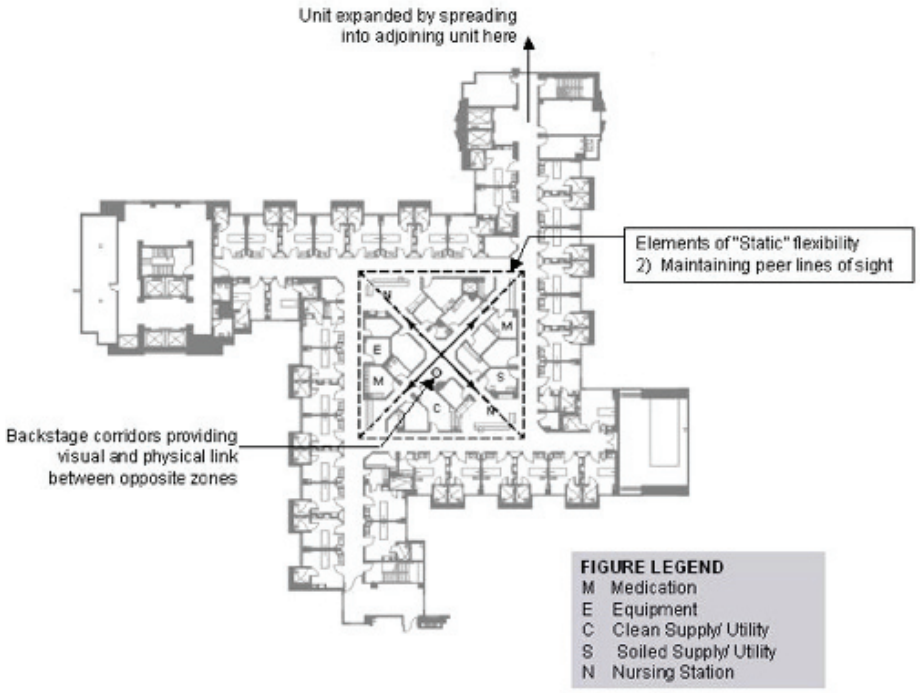


*Figure 6*. The medical-surgical unit at Laredo Medical Center, Laredo, Texas

Changes to service size are driven by sustained change in patient census. Across all the cases studied, census estimates (total census as well as census in a particular population group) during a hospital's planning and procurement change considerably once the facilities are occupied. As a result, services experiencing larger demand are expanded in size, frequently spreading into adjoining units. An example is McKay Dee Hospital Center discussed earlier, which also went through a parallel exercise of moving patient population in all units across and between floors until the appropriate fit of census and unit size was achieved. Similarly, Unit 3C in Laredo Medical Center was expanded to 38 rooms from an initial 34 rooms by spreading into the adjoining unit 3D (Firgure 6). In cases where physically adjacent units were not available for an easy "annexation", day rooms and other spaces on the units were converted to temporary beds pending facility expansion (St Rose Dominican Hospital, Siena – Figure 7).

Changes in nursing stations were also made at three facilities. Key reasons included: 1) spatial needs at stations increased (St. Francis Medical Center) as more inter-departmental operations move to inpatient units such as respiratory therapy, pharmacy and case management, and 2) station locations were incompatible with primary care-giving needs such as peer line of sight and patient visibility (Parker Adventist Hospital.)

In what way do the changes and operational challenges faced by care-giving staff inform us regarding physical attributes of inpatient care units? In the subsequent sections the authors make an attempt at articulating the flexibility issues arising from the above discussions, but from a different perspective. Discussion will focus on physical design decisions that are intricately related to the challenges and opportunities discussed previously.

## 4.5 Physical design and flexibility

Several attributes of the physical environment influence flexibility needs on medical-surgical units. Principal among these are unit size, unit shape, design of support core area, room design, and inter-unit/departmental circulation.

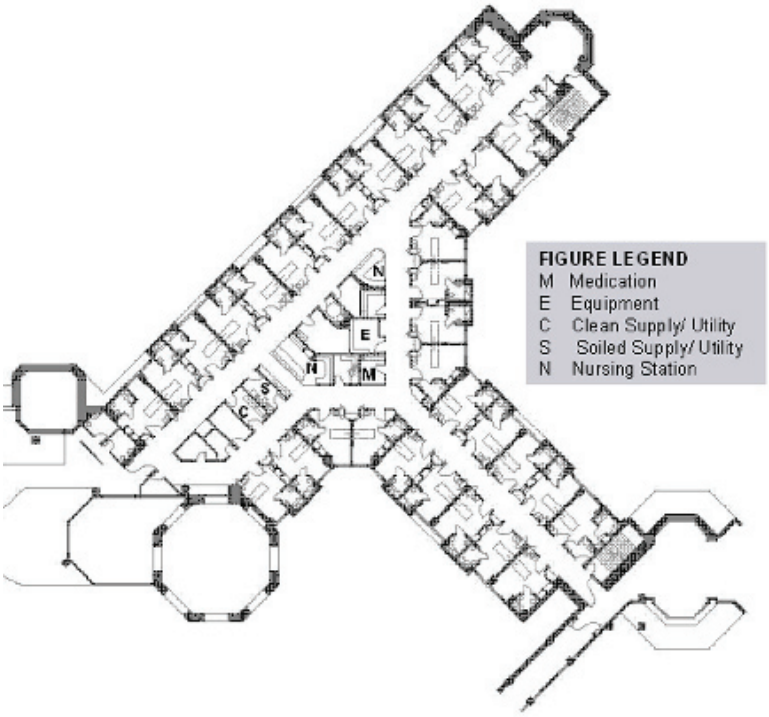


*Figure 7.* The medical-surgical unit at St Rose Dominican-Siena, Henderson, Nevada

### 4.5.1 Unit Size

Unit size has traditionally been driven operationally by considering the optimal bed numbers that a unit clerk can serve or that a unit manager can supervise. Unit size is also perceived to substantially affect flexibility to respond to fluctuations in service census. Large units of 40 or more beds, according to a senior-level nurse manager at McKay Dee Hospital Center, introduce a major hurdle to operational flexibility. Such units get exponentially chaotic, create large walking distances, and reduce operational flexibility. Chaos generated in large units can include traffic, noise, and other environmental stressors such as queues to complete tasks. According to nursing management staff at St. Rose Dominican–Siena, a unit size of 30-35 rooms creates the best situation for staffing as well as operational flexibility. One of the major influences of unit size is on the magnitude of walking staff does to conduct their tasks. With the introduction of single patient rooms, floor plates have greatly increased in size. The negative influence of walking distance, as described previously, has a major perceived impact on the flexibility of staff to attend to changing situations and needs (an aspect of operational flexibility).

Large administrative units, however, are sometimes created owing to a surge in patient census in a particular population group, as discussed previously. In such cases spreading to adjoining physical units offers a quick remedy. However, as pointed out earlier, in addition to chaos, walking distances, decreased visibility and stress, the increase in unit size introduces an element of uncertainty in the nursing staff. Such uncertainties could affect job satisfaction and staff retention. According to some senior nursing staff at McKay Dee, operation of two administratively individual units of 22 beds each is preferable to their one administrative 28-bed unit that expanded into adjacent unit to become a 44-bed unit. It implies that floor designs that facilitate the division of the floor into various types of administrative units will create administrative flexibility and reduce the impact of chaos and negative stressors on operational flexibility of staff.

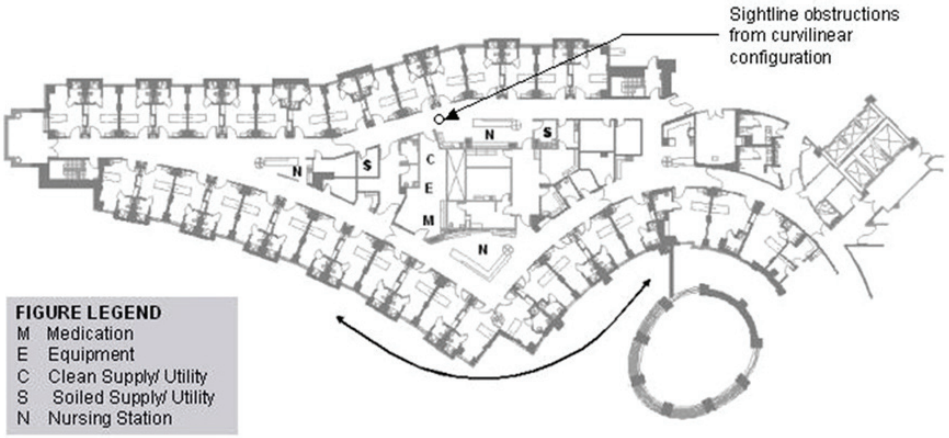


*Figure 8.* The medical-surgical unit at Parker Adventist, Parker, Colorado

### 4.5.2 Unit Shape

Closely associated with unit size is unit shape. Units have been designed around every basic geometric shape including the rectangle, square, trapezoid, circle, semi-circle, quarter-circle, triangle, and various modified versions of these shapes. Many complex shapes in bed unit design have been driven by a variety of factors including site constraints that limit buildable area, geometries that maximize opportunities for positive views, room groupings driven by programming and operational concepts, and physical configurations that enhance integration with adjoining or future bed units. In some ways unit shape is more important for flexibility than unit size, since it impacts a larger spectrum of operations within the unit, including staffing, teaming, lines of sight patient visibility (and hearing,) and dividing or zoning the core area for nursing support.

The shape of the unit determines the number of contiguous rooms that are available between turns on the units. When the number of rooms in a row does not match the staff, patient ratio, and flexibility in staff planning could be compromised, however in instances where the turn in room orientation encloses generally around the nursing and support core area, the spill-over of nursing assignment to adjacent rows does not constitute a major problem.

In many cases, configuration can critically affect staff assignment or staffing efficiency by impacting lines of sight, patient and room visibility, or perceptions on the part of the staff as to territory (patient rooms) for which they are responsible. Examples include where a rectangular, square or triangular race-track design is supplemented by small double-loaded corridor at each corner. From a space planning perspective, these double-loaded corners help optimize the unit size (number of rooms) with the corresponding required area for support core and circulation. However, when staffing assignments spill over to these corner corridors, it creates a nurse assignment perception considered physically and perceptually as separate room clusters as seen at Clarian West Medical Center. Patient visibility and peer line of sight are additional burdens associated with such assignments. All of these conditions have been described by unit managers to negatively impact the caregivers' innate sense of responsibility for patients in these zones unless all of their assigned patients are in the corner rooms – an example where design limits flexibility of assignment.

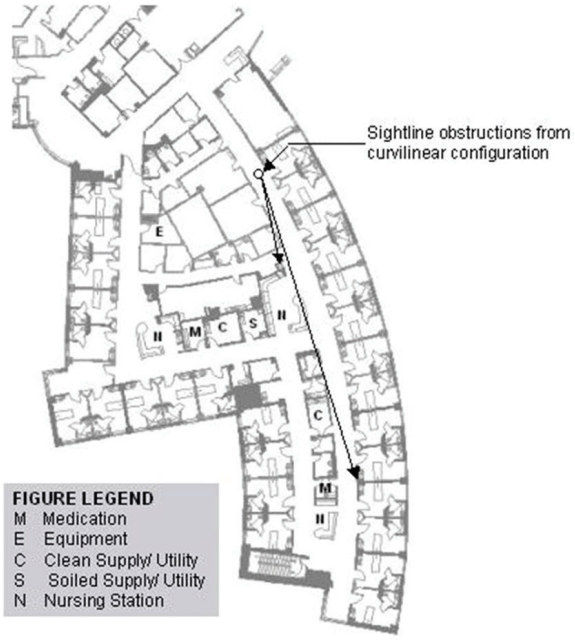


*Figure 9*. The medical-surgical unit at McKay Dee Hospital Center, Ogden, Utah

*Figure 10*. Gentle curve in circulation corridors leading to sightline obstruction at McKay Dee Hospital Center

Successful teaming of nursing staff is affected in almost all situations where staffing flexibility is affected. A fundamental requirement in successful teaming is in maintaining lines of sight by indicated at St. Francis Medical Center nursing managers. When lines of sight get disrupted, the perceptions of availability of support when needed and the perceived opportunity for consultation and socialization are impacted. Disrupted lines of sight do not solely originate out of modified primary shapes as described in the example above. They could arise from gentle curves incorporated in the unit circulation design (as shown in Figure 8, 9 and Figure 10). Such gentle curves that are typically provided with the intent to reduce perceived walking distances by staff hinder direct visibility of the nursing stations or peers in other cluster of room assignments. To generalize, when flexibility in nurse teaming is negatively affected, teaming of other support personnel is also compromised.

Unit shape and circulation patterns also contribute to another major problem in contemporary hospital design – that of way-finding, and hence indirectly to flexibility. Suggestions of multiple routes (for instance in regular shapes with modified corners; Figure 2 and 7) or in curvilinear circulation paths that obstruct visibility of prominent unit circulation nodes result in visitors losing their orientation on the units. Nursing staff at two units (McKay Dee Hospital Center and Clarian West Medical Center) report considerable time spent on providing directions to disoriented visitors and family members. Way-finding creates an additional non-essential burden on care-giving staff, thereby reducing their potential to adapt to changing and unpredictable situations in patient

In light of these discussions, what shape is most ideal for units to enable staffing and teaming flexibility while retaining lines of sight and patient visibility? This question was not directly addressed in this study, and certainly not answered by it. Hopefully the findings of this study will lead to more thoughtful investigation into configurations that are unequivocally better than others for flexibility. However, there is another component of unit design, entirely driven by configuration that warrants our attention as it relates to providing flexibility.

### 4.5.3 Support Core Areas

Design of the inpatient unit support core area impacts both short-term and long-term flexibility as well as staffing and teaming. Support core spaces include nursing communication areas (central or satellite nursing stations with patient charts,) nursing support services areas (clean and soiled utility and holding rooms, medication rooms, nourishment room, equipment holding rooms or alcoves,) and management, education, interaction and possible family support spaces (dictation and viewing rooms, ancillary care-giver work stations, offices, consult rooms, and class rooms.) In theory, other than the nursing communication areas, all other spaces could be located outside a unit. In practice, however, to reduce walking distances by providing close proximity of supplies and administrative work areas to the patient room, support cores are typically located at the physical center of the unit floor plate and assume the general shape of the overall unit (i.e. a square unit with a square core, a rectangular unit with a rectangular core.)

Design of the support core could impact staffing and teaming flexibility. Owing to its central location and its spaces requiring complete enclosure for code or privacy reasons, the core often limits lines of sight and visibility in a unit. That impacts staff productivity, particularly where room assignments turn corners or spill over to adjoining corridors. It is common in staffing assignments (owing to several operational constraints) that nurses are assigned to patients who are not in one contiguous set of rooms. In such cases the support core design could play a significant role in the degree of flexibility that nurses have (or perceive that they have.) The identical reasons affect teaming of staff. Obstruction of line of sight owing to the core design will affect visibility between peers.

Several design features help enhance flexibility. Placement of nursing stations at each corner of the support core provides one means of enhancing visibility of and accessibility to peers. Corner locations of nursing stations also help cluster rooms around each satellite nursing station, providing one way of dividing or zoning the rooms on the floor (an example is Laredo Medical Center, Figure 6.) When such nursing stations, however, are located within the physical periphery of a primary shape or are located within a curvilinear unit circulation design, they do not enhance the perception of peer availability or support to any large extent (an example is Parker Adventist Medical Center.) Further, such a "side-loaded" design feature only helps adjoining segments of a unit - units located on opposite sides of the core remain disconnected physically (to some degree) and visually.

Several features have the potential of contributing to flexibility through support core design. Protruding the satellite nursing stations outside the peripheral boundary of the support core could enable direct visibility between nursing stations. Incorporation of a restricted (backstage) corridor connecting the main unit circulation constitutes another possibility (an example is Clarian West Medical Center, Figure 11.) The most promising example was found in Laredo Medical Center (Figure 6,) where a set of diagonal backstage corridors connected the four nursing stations at each corner of the support core. Not only did that visually link all segments/zones of the inpatient unit, it also created an elaborate backstage corridor system for locating support spaces out of direct public view.

Beyond line of sight and visibility considerations, support cores could impact flexibility based on the way the unit as a whole enables zoning of patient rooms for material allocation from distributed nursing support areas. The chief problems originate from medication and clean supply rooms. As discussed before, improper zoning or division could result in a mismatch between room assignments and support core zone assignment (where the one closest is not assigned to support that room.) This leads to unnecessary walking and stress on the nursing staff. In essence, this problem is associated with: 1) the shape of the unit and the different ways it enables zoning/division for staffing, 2) the design and location of support rooms proximate to a select number of patient rooms, and 3) operational assignment of support rooms to patient rooms that remains consistent with the design concept.

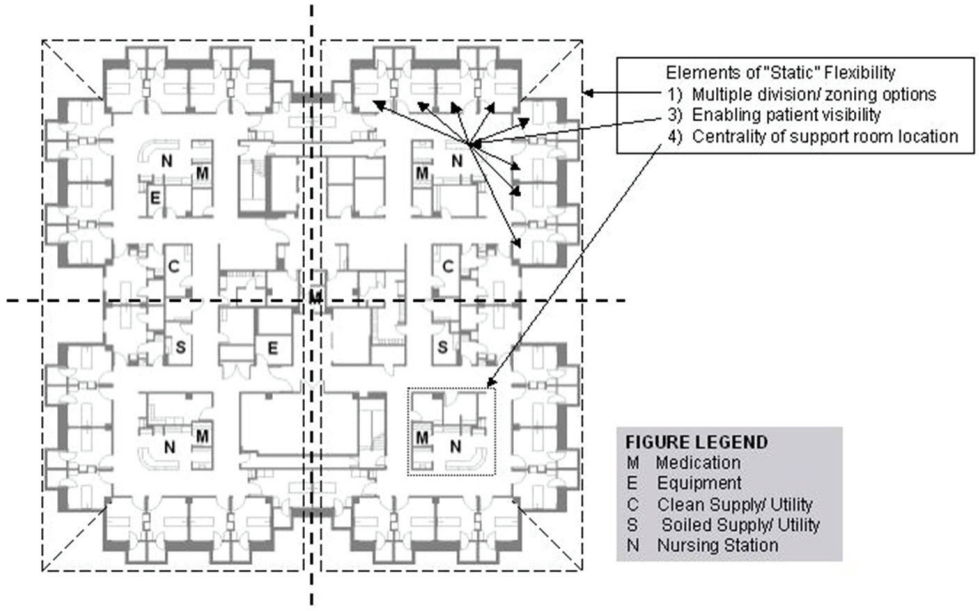


*Figure 11.* The medical-surgical unit at St Francis, Charleston, South Carolina, offering multiple options for size and zoning

A final issue related to support core area pertains to the earlier description of the problems with storage space availability, room sizes, and design of shelving and cabinetry. These problems have surfaced over time in all the facilities visited and appear to be common to all inpatient units in the industry. A frequent wish list of the respondents included the ability to: 1) create new spaces as needs arise, 2) effect minor changes to room sizes and shapes as needs change, and 3) change the shelving and cabinetry on a regular basis. From these and the previous discussions on support core flexibility several things can be explored, within budgetary constraints: 1) incorporate rolling stock for shelving, or modular shelving and cabinetry in supply rooms, 2) minimize walls containing MEP elements to more easily permit partition relocation, and 3) adjoin the unit to space that can serve as an extension of support core space (highly useful for shared support elements between units (e.g., Figure 9, McKay Dee Hospital Center.) Cost-benefit arising from flexibility and efficiency, in the long run, needs to be assessed for this very key area of need for occasional change in inpatient unit design.

### 4.5.4 Room and unit level adaptability

A common area in literature addressing flexibility in inpatient unit design has been patient room adaptability. The most frequently used concept is the universal room, and the related issue of acuity-adaptability. Arguments favoring universal rooms have been covered earlier. While this study data shows that universal rooms may not have achieved considerable success as a model of care, such rooms and some variations thereof have begun to influence flexibility in ways that was not originally conceived. For instance, in Parker Adventist, the hospital's nursing administration perceives a tangible benefit of the ICU-ready rooms for disaster preparedness (a unique dimension of convertible flexibility.) Reported outside of this study is the feedback from Hospital Administration at Clarian Hospital–West that these rooms have similarly provided great flexibility in moving service around as necessary to deal with short-term specialty census issues, yet another instance of convertible flexibility.

Standardized rooms (not classified as "universal") in several units of varying sizes helped McKay Dee hospital move patient population in response to fluctuating census to arrive at the optimum service location. This major advantage associated with room standardization was, however, not complimented by the core support spaces. Different units need different kinds of supplies and equipment that often requires different allocations of support space. As a result, the nursing support functions (primarily materials management) faced difficulties in adjusting to floor plans with different support core configurations. Standardization of whole units, as opposed to only patient rooms would, perhaps, significantly enhance the flexibility facilitated through design.

### 4.5.5 Inter-unit service flexibility

A final issue relates to allied caregivers and care support personnel who are responsible for multiple units that span across floors and wings in a hospital. A key physical design attribute that could help enhance flexibility for these personnel is the number and location of vertical circulation elements. While location and number of vertical service nodes is driven by a host of other factors, from the viewpoint of these personnel, elevators and staircases located close to the unit entrance (without having to go through long circulation corridors or public areas) has significant benefit, and should be a planning and design priority. For units located at the same level, reducing the walking distance necessary to traverse between units could bear potential positive implications. Interconnection of units at multiple points is one way to accomplish this goal. In fact, the use of mini-staircases (staircases linking only a few floors) located within the support core areas could help enhance this aspect of flexibility in patient care.

## 5. Discussions

The data available through this study offers an entirely new perspective to the conventional view on flexibility in healthcare settings, and in inpatient care units. Earlier literature discussed flexibility mostly as convertibility or expandability. Discussions on managing operational flexibilities and uncertainties on a diurnal basis and attributes of the physical environment that facilitate or impede the addressing of such sudden needed change within the inpatient unit have generally been limited. Provision, by design, of universal patient rooms, distributed nurse stations, and nursing support spaces are intuitive responses that are popular but not well-documented through rigorous evidence-based design studies. Perhaps, the notion that human adaptability can overcome architectural barriers to productivity and flexibility, however inadvertently designed, has perpetuated limited interest in studying these issues in greater detail. The discussions above suggest that the physical design plays a crucial role in facilitating or impeding human adaptability to changing workload demands, staffing patterns and operational situations. The physical environment, in both its real and its perceived state, regularly influences human performance and adaptability.

Irrespective of changes in technology, operations design, philosophy of service, and models of care, several things will remain constant over time in care-giving: 1) patient care will be primarily given by one or more nursing staff to a patient, 2) some form of a care-giving team will be assigned a group of patients, and 3) maximizing time spent at bedside in direct patient care activities will be a high priority for design. It is also likely, regardless of advances in technologies and care delivery models (such as video monitoring and E-ICUs,) that geographic zoning of the inpatient care unit will continue to be a design consideration in order to find a best practice balance between cost of space, equipment and support human resources for care and the maximization of direct care by the nurse.

What may change is: 1) the way support services (medication, supply, food) are delivered to care-giving teams, 2) how sanitation and infection control standards are met, 3) how all forms of communication are facilitated between all parties to the care experience, and 4) how non-patient parties are assimilated into the care plan and care environment. Considering the projected shortage of trained nurses and other allied care-giver personnel, it is possible that the need for care-giving staff to be multi-skilled and able to adapt to changing situations and demands may increase over the next decades. From such a perspective, physical design attributes that facilitate or hinder personnel flexibility assume considerable importance in the short as well as long-term.

For the various dimensions of personnel and operational flexibility discussed in this report, several attributes of the physical design assume importance. To summarize the study findings, attributes that hinder flexibility include: 1) unit sizes and shapes that do not allow efficient variations in geographic zoning/division of rooms and support cores, 2) long walking distances within units, 3) peer line-of-sight obstructions, 4) improper or inadequate patient visibility and audibility, 5) inefficient inter-unit and inter-department circulation links, and 6) complex circulation that inherently introduces way-finding problems.

This view of flexibility, coincidentally, introduces an issue in physical design that adds a new perspective to the traditional notions discussed in professional literature. Based on the data collected in this study, this notion suggests that there are certain attributes of the physical environment that need to be 'static' to enable personnel and operations to be flexible in an inpatient unit over time. Those attributes have already been alluded to in previous sections, and include: 1) multiple division/ zoning options, 2) peer lines-of-sight, 3) patient visibility, 4) centrality of support, 5) resilience to move/relocate/ interchange units, 6) multiple administrative control and unit spread options, and 7) ease of movement between units and departments. Coupled with minimization of walking distances and reduction in disorienting (way-finding) factors, the above attributes could ensure flexibility in short as well as long-term. This notion of flexibility, in essence, constitutes a type of 'adaptable' flexibility from a clinical operations perspective – the ability of an inpatient unit to accommodate diurnal, short and long-term changes in census, staff, and other vital aspects of the clinical operations without any change in the environment itself.

The question that follows is whether there is a right prescription of unit shape, size, circulation, and support core design that addresses these flexibility needs. More importantly, does that begin to curtail creativity in design? On the contrary, it could be argued that any shape, circulation configuration, and support core design that incorporate the above attributes would facilitate flexibility. Incidentally, one or more respondents in all six hospitals visited came up with references to a circular or semi-circular design in their past experience that they perceive as having responded to all of the aforementioned flexibility needs. What is lacking in those circular or semi-circular room configurations is the notion of centrality of support core and minimization of environmental irritants (mostly noise that is or may be exacerbated and magnified in circular spaces.)

However, the key argument is not in the shape 'circle' but the 'attributes' of a circle and other shapes that retain the fundamental attributes of a circle while incorporating the seven 'static' attributes articulated above. Among the units studied, the shape that retains most of the attributes of a circle is a square (such as in Laredo Medical Center, Clarian West Medical Center and St. Francis Hospital shown in Figures 2, 6 and 11.) Evidence from the three suggests (notwithstanding the problems associated with the modified square shape and opaque cores discussed above) that the square may indeed be addressing more areas of static flexibility than other shapes, but this does not mean that other shapes that retain the attributes mentioned above should not be explored. Within the study sample, square shapes produce room configurations that are amenable to division/zoning in many ways for staffing and teaming flexibilities. In squares, spilling room assignments across corners leads to fewer disruptions in peer lines-of-sight and patient visibility. Squares allow support cores that can be divided and zoned in a number of ways. Adding nursing units at each corner and diagonal backstage corridors connecting each pair of nursing units retain visibility and line-of-sight requirements in the entire unit. And squares offer an ideal long-term flexibility option for static flexibility issues.

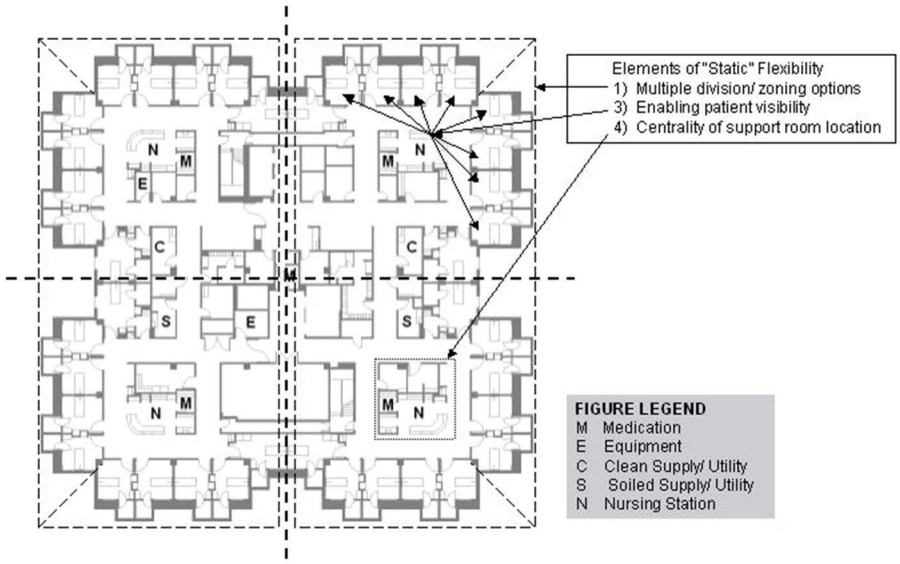


*Figure 11.* The medical-surgical unit at St Francis, Charleston, South Carolina, offering multiple options for size and zoning

The bed tower in St. Francis Hospital (Figure 4) demonstrates this point. It was designed as four pods with ten rooms in each pod. Over time, constraints in unit operations warranted a different unit configuration. When St. Francis Hospital decided to build an additional floor on top of the existing bed tower after ten years of occupation (when the operational assumptions made in the original design were obsolete,) they decided to build two 18-bed pods instead of four 10-bed pods, while retaining most of the positive features of the 4-pod design – a flexibility offered by a square unit.

Square and circular configurations, however, could result in excessively large cores depending upon unit size. Other shapes and configurations that support such long-term retention of static attributes are worth exploration in design research. The rectangle, a frequently used shape, continues to be a logical option for larger units, and worth exploring in future research studies. Theoretically, however, unit shape and configuration such as those in Parker Adventist (Figure 8) and St. Rose Dominican Hospital, Sienna (Figure 7) could be further manipulated to incorporate all the static attributes mentioned above, thus allowing designers greater liberty in decisions regarding form.

The second notion of inpatient unit flexibility relates to 'dynamic flexibility' of physical design elements. Convertibility and expandability issues related to support core areas constitute a major candidate for dynamic flexibility, which are already addressed in previous discussions. In contrast to 'static' attributes of the physical environment, dynamic flexibility is associated with the ability to change components of the physical environment. Within the support core, dynamic flexibility entails the ability to move walls, change sizes and shapes of rooms, change shelving and cabinetry, and expand the support core if the needs arise. Dynamic flexibility in patient rooms is already covered extensively in professional literature, including such ideas as replacing solid corridor walls with glass and adding medical gases for preparing rooms for intensive care. Flexibility associated with traditional head walls versus columns, multiple provisions for charting and documentation, and similar issues is also covered extensively in past literature. In light of availability of existing literature on room level adaptability, we are excluding any extensive discussions on such issues. Our principal emphasis in this document is on the 'static' attributes that contribute to operational flexibility at the inpatient unit level; a notion that supplements traditional thoughts on flexibility in a significant manner.

It may not be erroneous to assert that typical considerations for flexibility in healthcare design centers on convertible and expandable flexibility. The findings of this study suggest that adaptable flexibility at inpatient unit level can be enhanced during design by evaluating the design against a checklist of desired environmental characteristics. In line with the static attributes and impediments introduced above, the following is a suggested checklist for designers:

1) To what extent will the unit configuration allow flexibility in dividing the units for incorporating nursing support areas?

- Context: Based on nursing assignment the nursing management divides the unit into groups of rooms with corresponding support core area.

2) From various work zones, to what extent does the design enable visibility of peers within ones general cone of vision? How many peer locations are visible from each nurse location? Are there potential blind spots?

- Context: despite technological advances, direct visibility of peers enhances operational flexibility and efficiency and provides a sense of safety and security for caregivers.

3) From various work zones, to how many of the patient rooms are visibility and audibility obstructed? Are there certain nursing models for which room assignments can spill over corners?

- Context: higher acuity in medical-surgical units combined with an ageing patient population is necessitating direct sensory links to patient rooms, a factor with considerable impact on operational flexibility.

4) For each group of rooms intended for nursing assignment, how proximate are the assigned nursing support areas? Is there undue walking involved in gaining access to support services?

- Context: large, unwarranted walking distances constitute one of the foremost impediments to operational flexibility.

5) To what extent will the unit design support different types of patient population?

- Context: moving services across floors or units enhances efficiency and flexibility of operation.

6) To what extent does the design of the floor on which the unit is situated allow resizing services in response to changing census? To what extent does the floor design provide the ability to reconfigure administrative units?

7) To what extent will the design of vertical and horizontal transportation systems reduce physical demand on personnel servicing multiple units and departments?

- Context: Hospital personnel responsible for several units within the hospital are required to travel to several areas in a time-efficient manner.

8) To what extent does the design promise to reduce disorienting effects on visitors and family members?

- Context: Staffs are frequently interrupted to provide directions to visitors and family members despite signage in a unit.

Despite these very informative findings, this study is essentially exploratory in nature and the sample consisted of designs from one design firm, and, hence should be considered with appropriate understanding of these limitations. Future studies should consider expanding the sample for greater generalizability as well as more objective assessment of flexibility needs in inpatient care units, based on the findings of this study.

Further, bed unit operations are not entirely insulated from the flexibility needs of the rest of the hospital. While the data collected did include flexibility issues associated with major departments that support nursing, this document is intentionally limited to discussions on bed units. Future studies could and should begin to link micro and macro flexibility needs and design issues arising out of such needs. Nevertheless, this paper constitutes a unique and important contribution to our understanding of flexibility in architectural design for inpatient care units - a topic not widely published in research literature to date. This major component of the healthcare building-type will receive substantial investment over the next decade and beyond, driven by dramatic changes in the U.S. population and demographic make-up in the future. Healthcare facilities demand high performance in terms of operational efficiency, patient safety, consumer focus and satisfaction, staff attentiveness (hence retention,) sustainability, and longevity of useful service. Outside of sustainability to deliver a productive life of 25 – 40 years, flexibility is the most important characteristic that design must impart as ra demonstrable legacy of the architect, evidenced by long-term adaptability to whatever changes the healthcare industry might bring to bear on the product. This study constitutes a preliminary but important step in that direction.

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