Development of Tools for Healthcare Environments Research and Practice

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edra

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Contents

Introduction

HOK GLOBAL

HOK is a global design, architecture and planning firm. Since our founding in 1955, we have used design to enrich people's lives and help organizations succeed. Our 1,600 people collaborate across a network of 26 offices on three continents. HOK's mission is to deliver exceptional design ideas and solutions for our clients through the creative blending of human need, environmental stewardship, value creation, science and art. Our design solutions result from a collaborative process that encourages multidisciplinary professional teams to research alternatives, share knowledge and imagine new ways to solve the challenges of the built environment.

Human need is the foundation of our creative process. Everything we do responds to the needs and aspirations of our clients and their communities. HOK's approach emphasizes an integrated design process utilizing research, analysis and design insight to drive innovation. Our geographic and cultural diversity expands our knowledge, and allows us to craft solutions that create real value.

HOK RESEARCH

Research informed-design solutions have been shown to elevate the quality of care delivery and decrease costs in an unpredictable industry struggling for financial efficiencies. Long-term clinical, strategic and business advantages can be realized for facilities through using research and operational decision-making. Thoughtful research and analysis identifies ways to target an organization's key performance indicators, such as facilitating care-quality, or attracting more patients and staff.

Design research takes the pulse of a facility. The research is applicable to any stage of a facility's lifecycle, from master planning to post-occupancy. Results can feed-forward to future design and operational efforts.

Research tools are integral to providing new ways to reliably examine the impact of design decisions. In addition, consistent tools advance the level and integration of research in any field through facilitating comparison across multiple sites and study sites over time. Currently, the field of healthcare design research lacks a standard set of tools and metrics for doing just that. The metrics and methods shared through this document are an important step in building a toolkit for healthcare design research and provide a resource to for future researchers.

HOK values research as both a part of the design practice and a way of furthering thought leadership. We are excited to support this publication as a way to contribute to the field of design research and to create better healthcare for all.

Executive Summary

A growing body of research has shown that the design of the healthcare built environment contributes to a safe and healing environment for patients and a nurturing, positive environment for staff, as well as helping achieve organizational and business objectives. An evidence-based design process involves using the best available research to inform design decisions and then conducting research to evaluate the effectiveness of design interventions. While this field has been growing over the last decade, current challenges to growth and development **include the lack of standard metrics and measurement tools for measuring environmental as well as outcome variables.** The purpose of the EDRA Tools Intensive in 2012 was to bring together a community of researchers who have been involved in developing various tools to measure both environmental variables as well as outcomes. While the focus of this session was on healthcare environments, tools and metrics developed in other types of settings that may be relevant in healthcare environments research were also discussed. The session included:

- Presentation of a framework and glossary of healthcare environments terms and measures developed by the Center for Health Design (CHD).
- Presentations by researchers on existing tools, or tools under development, that could be relevant to research on healthcare environments.
- Discussion on key considerations for development of reliable tools and metrics for Evidence-Based Design research.
- Discussion on how tools that are developed could be made available to the industry to advance the incorporation of research in practice, and how questions raised in practice could be the impetus of academic endeavors in developing tools and metrics.

This publication is a compendium of ten short essays that were published by session contributors, including some authors who were unable to present in person.

The first paper in this compendium is a primer of the Evidence-Based Design Glossary published by the Center for Health Design. The purpose of the EBD glossary was to provide a better understanding of key variables, metrics, and measurement tools currently used in EBD research. This work provides a crucial foundation by enabling CHD as well as others to develop more accurate definitions of terms and variables, to develop more powerful metrics and tools, and eventually to enhance the quality of EBD research and practice. The EBD glossary is the first step of a multi-year effort by CHD to develop tools and resources that support not only the use of research findings in the design process, but also support new research studies in this area.

In the second paper, Dr. Upali Nanda discusses the role of health outcomes in research on the built environment. Through the case example of visual art and nature images, she makes the case for how design can impact measurable physiological outcomes, and how research methodology that looks at compelling clinical outcomes can aid in making the business case for investing in healthcare design. She also shares a case study on using existing metrics, such as the rate of as-needed mediation dispensed to reduce patient anxiety, to investigate the impact of focused environmental interventions. Such metrics have the added advantage of a direct translation to saved dollars, which can make a business case against the value-engineering of design elements.

In the last few decades, psycho-social research has made tremendous headway. We have increasingly sophisticated tools to measure human response. Where there is still a challenge is in being able to measure the components of the physical environment, in all their complexity, to correlate to the human response. This is essential to determine where we succeed and where we fail in design.

The plan is the fundamental deliverable in architectural design, and one that is highly complex to measure. How do you measure the "quality" of a plan, beyond its dimensions? Dr. Saif Haq introduces us to the use of space syntax as a tool in research on healthcare environments, which allows a tangible measure of the configuration of the plan based on connections. The paper is an excellent primer on space syntax for all design researchers and practitioners.

In their paper on nurse station typology, Dr. Hui Cai and Dr. Craig Zimring provide a case example for the use of space syntax as a tool that links connections in the plan (in terms of visibility) to the mechanisms of communication and coordination, as well as to the targeted outcome of improved work efficiency. They share the use of a program "Depthmap" to conduct spatial analysis and describe visibility patterns and behavioral data from nurses to test the validity of the proposed spatial metrics. The spatial metric tool developed by the authors provides a new way to measure and evaluate nursing units, beyond the traditional classification into centralized, decentralized, and hybrid layouts.

While space syntax provides us with a method to compute design parameters, a key component of design research is the ability to visualize space and analyze its challenges and opportunities before it is built. In the paper on simulation research, Derrek Clarke and colleagues bring together the component of behavioral observation from environmental psychology and apply it to the cutting-edge technology of simulations. They share how behavioral observation is a tool for studying human behavior in existing environments, as well as conceiving human behavior in un-built environments. The paper also provides an introduction to different kinds of simulations and mock-ups and their relevance to the field of design.

A primer on field observations to observe how users "behave" in a particular environment through systematic observations in the field is provided by Dr. Zhe Wang's paper, which outlines two customized tools that she has developed which can be used at different stages of the design process. She shares with the readers a template for field observations, as well as two case studies for how the template was adapted and used in an infusion center and an ICU corridor.

Another aspect of field observations particularly relevant to the case of nursing efficiency is the issue of staff walking distances. In his paper on reducing system waste, Dr. Debajyoti Pati discusses how different tools that are commonly used to measure staff walking, such as pedometers and custom-installed radio-frequency/ infra-red tracking systems, have proven to have low reliability or astronomical costs. He shares with readers the development of a validated nurse walking predictor measure that he has developed which combines nurse locator system data and CAD drawings to develop a systematic and rule-based protocol for measuring walking in hospital units.

In the context of dementia care, the issue of walking is closely linked to the issue of wandering, as well as potential risk of falls. Of great importance in such settings is being able to locate the patient. In his paper on location aware technologies, Dr. William D. Kearns and Dr. James L. Fozard share the development and use of a Real Time Location system and Wander-Track to study resident paths and spatial usage patterns, which can measure movement variability related to cognitive impairment in order to provide an online assessment of resident cognitive abilities and fall probability. The tool described is unique in its ability to evaluate the broad or specific environmental changes on human behavior by precisely tracking the location of the wearer at rates of several Hertz (Hz) as they move about their environment. It also allows the ability to assess fall risk in dementia care settings which is has tremendous safety implications.

Dr. Habib Chaudhury and Heather Cooke look at the role of the physical environment for dementia care within a broader framework and discuss various tools that seek to assess the built environment of dementia care settings. They discuss how the existing tools are based on generalizations in understanding the built environmental aspects and behavioral associations, and overlook personal characteristics and the resultant variability of interrelationships between the individual persons with dementia and the physical environment of their setting. They share with the readers how they developed an environmental evaluation component designed to function along with a well-known dementia care evaluation tool—Dementia Care Mapping (DCM)—to address some of these issues. The resulting tool, DCM-ENV, has great potential to provide a comprehensive assessment of user-environment interactions, and the method holds lessons for healthcare settings beyond dementia care.

The final paper in this compendium takes us back to ICU settings. Dr. Mahbub Rashid and his colleagues share the development of nurse and physician ICU questionnaires that can serve as reliable and valid measures for describing and assessing the design of ICUs and work environments. This paper not only shares a new tool to assess how nurses and physicians respond to the designed environment, but also provides key insights into the methodology involved in developing reliable and valid questionnaires. Questionnaires are arguably the most frequently used metric in design research. The last two papers in the compendium allow readers to understand how reliable and valid questionnaires are developed, along with offering examples of two robust tools.

Valid and reliable tools and well-defined metrics form the basic building blocks for any good research study. Many studies that examine the impact of the built environment on outcomes often do not define the environmental variable effectively. As a result, the findings from such studies are difficult to implement in practice and such studies are also difficult to replicate. The tools shared as part of this session make a strong contribution to the field by enabling researchers and practitioners to measure the physical environment effectively. In many ways, this session marks the start of an effort by researchers in this field to build a toolkit of tools and resources that can support researchers and practitioners. We thank EDRA for its crucial role in bringing this community of researchers together and in supporting the development of this compendium.

Anjali Joseph and Upali Nanda

A Glossary of Healthcare Built Environment Terms and Measures

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The design of healthcare facilities is an inherently complicated process involving interdisciplinary teamwork among healthcare administrators, planners, programmers, designers, clinician and patient representatives, and others who have different backgrounds and professional languages. Communication between stakeholders during the facility design process, especially while using evidence to inform design and creating evidence by empirically evaluating the built environment, becomes difficult due to a lack of common understanding of terms and measures. There is a need for a set of standard definitions of key terms and measures used in healthcare design—this base knowledge would make it easier to communicate with team members, interpret and translate research studies to design knowledge, generalize studies to different types of settings, compare data across multiple facilities, and develop a central repository of evidence.

In October 2009, The Center for Health Design (CHD) initiated a project to develop a standard glossary for evidence-based healthcare design (EBD). The first phase of the project aimed at: (1) identifying environmental variables and outcome measures in the existing EBD research; and (2) examining how these variables and outcomes were defined and measured in seven high-priority topic areas:

- Healthcare-associated infections (HAIs)
- Medical errors
- Patient falls
- Patient satisfaction
- Patient waiting
- Staff efficiency
- Staff satisfaction

A better understanding of key variables, metrics, and measurement tools currently used in EBD research will provide a crucial foundation for future phases of this project by enabling CHD as well as others to develop more accurate definitions of terms and variables, to develop more powerful metrics and tools, and eventually to enhance the quality of EBD research and practice.

This paper provides a synopsis of the EBD glossary terms, metrics, and measurement tools extracted from the literature as well as the process of the first phase. Because of space limitations, only a small sample of the results is presented here. The complete results, including a full research report, literature analysis tables, glossary tables, and conceptual frameworks are available at CHD's website (www.healthdesign.org/chd/research/healthcareenvironmental-terms-and-outcome-measures-evidence-based-design-glossary).

METHODS

The CHD research team worked together with experts from CHD's Research Coalition to conduct a literature search and review. The literature review focused on peer-reviewed research articles that empirically demonstrated the effects of environmental variables on healthcare outcomes in each of the seven topic areas. The relevant articles from CHD's previous literature reviews (for example, two comprehensive literature reviews by Ulrich and colleagues [2004, 2008]) were retrieved. Publications after CHD's previous literature reviews were searched in research databases such as PubMed and EBSCO. Additional articles came from the reference lists of existing articles and the recommendations of academic and industry experts.

The articles were sorted and sifted for detailed literature analysis, with the goal of creating a comprehensive list of variables as well as metrics and measurement tools. The purpose of the literature review was not to exhaustively review all articles on a particular subject. Rather, the goal was to review a sample of articles in different topic areas that had an empirical focus and clearly defined environmental and outcome variables. Each selected article was analyzed to extract relevant information including the environmental variable(s) and outcome(s), metrics, measurement tools, sample(s), setting(s), research design, and findings. The results of the literature analysis included a series of tables and a chart for each topic area:

- An article analysis table including the extracted information from each individual article together with the reference information;
- A matrix showing the co-relationships between environmental variables and outcomes in a table format;
- A model/conceptual framework depicting the relationships between environmental variables, intermediate environmental quality variables, and outcome variables; and
- A glossary table synthesizing all variables (including their definitions), metrics, and measurement tools used in the studies reviewed.

Finally, the seven glossary tables for individual topic areas were combined into one glossary table of healthcare environmental variables and one glossary table of healthcare outcome variables.

FINDINGS

A total of 50 environmental variables and 35 outcomes were identified (shown in alphabetical order in Table 1) in the seven topic areas. Certain environmental variables may be associated with multiple outcomes in various topic areas. For example, the environmental variable "interior finish material" (e.g., carpet flooring vs. vinyl) was related to both the "bacterial growth" on interior surfaces (an outcome measure in the topic area of HAIs) and the risk of "fall-related injuries" (an outcome measure in the topic area of Patient Falls). The relationships between the variables are illustrated in the models/frameworks in the full report.

Environmental and outcome variables or terms (including relevant topic area[s] in the parentheses), the definition, metrics, and measurement tools are included in the glossary tables in the full report (available at CHD's website), of which only a small portion is shown in Tables 2 and 3.

Environmental Variables, Metrics, and Measurement Tools

The environmental variables were typically measured on a categorical scale. In other words, many studies examined the outcomes under different environmental conditions, such as decentralized versus centralized nursing stations and alcohol-based hand rub dispensers versus water/soap sinks. However, a great challenge in EBD research and practice is that some environmental variables or terms are not well defined in a quantifiable way. A variety of environmental conditions in different studies or study sites may bear the same name even though there are considerable differences between them. For example, the term "decentralized nursing station" has been used to describe various unit configurations with more than one nursing station per unit, ranging from two to 11 patient beds per nursing station in one study (Zborowsky, Bunker-Hellmich, Morelli & O'Neill, 2010). This inconsistency or variation in using the same term in different study sites and publications poses threats to the validity as well as the generalizability of research. Although some articles provided descriptions (including floor plans and photos) about the study conditions, it is still probable that certain readers may over-generalize the findings while ignoring the significant variations underlying the same name.

A relatively smaller number of environmental variables were measured on an interval/ratio scale where the distance between values indicates how different they are. For example, the ventilation rate was measured by air changes per hour or cubic feet per minute, and one metric of the relative number of handwashing devices was the bed-to-sink/dispenser ratio.

In most studies, environmental variables were manipulated by designers or researchers as independent variables. Other studies measured the environmental variables by using a variety of methods, including subjective measures such as ratings of physical environment attractiveness and objective measures using technological methods such as photometer measurement of illumination level and tracer gas concentration decay technique for the calculation of ventilation rate.

Outcome Variables, Metrics, and Measurement Tools

Compared with environmental variables, healthcare outcome variables were relatively better defined with more standardized metrics and measurement tools. However, it is not uncommon to find controversies and weaknesses in the definition and measurement of key outcome variables. For example, there is not a universally accepted definition of patient falls. Further, most studies in patient falls relied on incident reports completed by staff members to determine the rate of patient falls and other related outcomes. The practice of incident reporting varied significantly across different studies and hospitals and was believed to underestimate the actual rate of falls.

Almost all outcome variables were measured on an interval/ratio scale. Metrics of patient safety outcomes typically included the prevalence of safety incidents (e.g., number of infections or patient falls per 1,000 patient days) and the severity of consequences (e.g., severity levels of medication errors: 1-little or no effect on patient to 5-ikely to lead to death). These outcomes were often collected by reviewing incident reports and medical records except for medication errors, which were often measured by directly observing and evaluating medication processes. One large group of outcomes including patient and staff satisfaction, stress, perceived patient waiting, staff burnout, and staff turnover intent were subjective ratings collected by questionnaire surveys. Direct observation was a key method of measuring behaviors of patients and staff such as handwashing compliance. Several outcomes (e.g., surface contamination, staff travel, and staff stress) lend themselves to technological measurement methods including electrocardiography monitoring, saliva sampling and radioimmunoassay analysis, air sampling using biocollectors, biology analysis, and indoor positioning systems. Computer simulation is a major method in evaluating behaviors and performance of surgeons and pharmacists.

CONCLUSIONS AND NEXT STEPS

As a critical step toward a standard EBD glossary, this first phase of work not only generated essential and useful resources for healthcare design and research but also identified the current status, including strengths, weaknesses, and gaps in the term definitions, metrics, and measurement tools. The future phases of this project will also rely on the contributions by interested multidisciplinary volunteers from the field for glossary revisions and additions. One critical component of the glossary development is to obtain input, feedback, and recommendations from key stakeholders through online and face-to-face discussion (including the online interface at CHD's website and the two roundtable sessions on the EBD glossary at HCD conferences in 2010 & 2011). Further, additional topic areas (such as staff injuries) and additional sources of environmental terms and healthcare outcome measures will be examined with helps from academic institutions and others. With the growth of research in the field, the list of environment variables and outcome measures would be updated and expanded regularly.

Table 1: Healthcare environmental variables and outcome measures.

Healthcare Environmental Variables	Healthcare Outcome Measures
Acoustic ceiling tile	Adverse drug event (ADE)
Acuity-adaptable room	Anxiety
Air pressure difference between adjacent spaces	Bacterial growth
Alcohol-based hand rub	Bioaerosol concentration
Amenities	Burnout
Antimicrobial-finished textile product	Circadian misalignment
Attractiveness, physical environment	Cleaning, thoroughness of terminal cleaning
Bar-code-assisted dispensing system	Endotoxin concentration
Bed alarms, medical vigilance system	Fall-related injuries
Bedrail and other physical restraints	Falls, patient
Bedside assortment picking (BAP) trolley	Hand hygiene compliance
Computerized physician order entry (CPOE)	Job satisfaction
Computerized (automatic) reminder of hand hygiene	Length of stay
Copper-silver ionization system	Medication administration procedural failure
Daylight	Medication errors
Distraction	Medication processing time
Emergency department layout	Mortality
Falls, multifaceted environmental intervention	Nosocomial infections
Hand hygiene devices, number of	Nurse response to patient call
Head-mounted display	Particulate level
High-efficiency particulate air (HEPA) filter	Patient colonization
HEPA filters, location of	Patient loyalty
Illumination level (illuminance)	Perception of physical environment
Information access	Satisfaction, patient
Interior finish material	Staff travel
Interruption	Stress, staff
Laminar air flow	Surface contamination
Light fixture (luminaire)	Surgeon/anesthesiologist performance
Medication distribution system	Surgical errors
Mobile air-treatment unit	Team communication
Music	Transport, intra-hospital patient transport
Noise	Tuberculin conversion and reactivity
Nursing station layout	Turnover intent
Nursing unit shape/layout	Waiting behavior, patient
Patient bathroom design	Waiting time, patient
Patient room layout	
Patient room occupancy	
Pharmacy equipment	
Physical configuration of drug stock shelves	
Physical proximity	
Positive distractions	
Rapid assessment clinic/pod/zone	
Subfloor	
Surface cleaning	
Ultraviolet germicidal irradiation	
Ventilation grilles, location of	
Ventilation, natural	
Ventilation rate	
Wireless technology	
Workroom layout	

Table 2: Selected examples of environmental variables, definitions, metrics, and measurement tools.

Term (Topic Source)	Definition	Metrics	Measurement Method
Acuity-adaptable room, including single-room maternity care (Medical errors, Patient satisfaction, Staff satisfaction)	Rooms designed with sufficient space and provision for equipment, medical gases, and power to accommodate any level of patient acuity (Evans, Pati & Harvey, 2008). Single-room maternity care refers to maternity care rooms where families are admitted and stay throughout the intrapartum and postpartum periods. The rooms are spacious and include amenities for families. They differ from the traditional care model which requires patients to transfer between multiple rooms, depending upon their care status. (Janssen et al., 2001).	Yes/no, before/after (Hendrich, Fay, & Sorrells, 2004; Janssen et al., 2001)	**Design manipulation** The coronary critical care unit and medical step-down unit were redesigned and combined into one acuity-adaptable unit (Hendrich, Fay & Sorrells, 2004). Survey responses from a same group of nurses were collected six months before and three months after moving from a traditional unit to a single-room maternity care unit (Janssen et al., 2001).
Illumination level (illuminance) (Medical errors, Staff efficiency)	The intensity of luminous flux (Stein, 1997).	Lux (1 lux=1 lumen/m2) Footcandle (1 ftc = 10.764 lux) Bright light versus normal room lighting (Crowley et al., 2003)	**Photometer** Photometer (model IL1350, serial 2048, International Light Inc., Newburyport, MA) with an illuminance sensor (model SCD110, serial 1366, International light). Eight measurements were taken, starting 6 inches from the end of the conveyor belt and every 12 inches thereafter. The amount of illumination represents the mean of the eight measurements taken daily for seven days (Buchanan et al., 1991). **Design manipulation** Bright light (BL) exposure during night shifts compared with normal room lighting. Bright light (~5000 lux) was produced by three light boxes (61.0 cm wide, 77.5 cm high, 12.1 cm deep, cool white fluorescent lamps, Apollo Light Systems Inc., Orem, UT) set on the perimeter of a large, round table facing the center of the table. Normal room light is about 150 lux (Crowley et al., 2003).
Light fixture (luminaire) (Medical errors)	A complete lighting unit consisting of a light source (one or more lamps), and the parts designed to position the light source and connect it to the power supply. Parts for protecting the light source or ballast and for distributing the light may be included. (National Fire Protection Association, 2010)	Different lighting conditions determined by supplemental lighting fixtures and color filters (Buchanan et al., 1991)	**Design manipulation** The installation of supplemental light fixtures and the removal of color filters (Buchanan et al., 1991)
Ventilation rate (HAIs)	The rate at which air enters and leaves a building, space, or room (EPA, n.d.).	Air changes per hour (ACH) Cubic feet per minute (CFM) Cubic meter per hour (absolute ventilation rate) (Escombe et al., 2007)	**Tracer gas concentration decay technique** With all windows and doors closed, carbon dioxide (CO2) was released and mixed well with room air using large fans to create a spatially uniform CO2 concentration in the room. CO2 concentrations were measured throughout the room at one-minute intervals using a centrally located infrared gas analyzer. ACH were calculated as the gradient of the straight line through the natural logarithm of CO2 concentration plotted against time in hours (Escombe et al., 2007; Menzies et al., 2000)

Table 3: Selected examples of environmental variables, definitions, metrics, and measurement tools.

Term (Topic Source)	Definition	Metrics	Measurement Method
Medication processing time (Staff efficiency)	Amount of time from when a prescriber orders medication, to the pharmacy receiving the order, to the pharmacist completing the order (Wietholter et al., 2009).	Prescription filling time (Lin et al., 1988; Wietholter et al., 2009) Pharmacist travel distance for filling prescriptions (Lin et al., 1988)	**Computer simulation** Prescription filling time measured by computer simulation using a predetermined motion time system (PMT systems), standards determined through consultation with supervising pharmacist and videotaping of pharmacist work (Lin et al., 1988) **Medical records** Review of medication records (Wietholter et al., 2009) **Measurement on architectural drawings** Pharmacist travel distance for filling prescriptions was measured and calculated using architectural drawings (Lin et al., 1988)
Patient colonization (HAIs)	Isolation of a targeted pathogen (organism) from the patient (e.g., sputum, wound surface, urine, stool) (McManus et al., 1992).	Percentage of patients colonized Postburn time delay in colonization (McManus et al., 1992)	Microbiology surveillance Microbiology surveillance was performed for the first 30 days of hospitalization or longer if patients remained in the unit. The surveillance included weekly cultures of sputum, wound surface, urine, and stool. Colonization was defined as isolation of the organism from any site on the body (McManus et al., 1992)
Patient loyalty (Patient satisfaction)	Patient's long-term commitment to a preferred healthcare service provider; a manifestation of attitudes and actual purchasing behaviors (Hsu, Hsu & Chiu, 2009)	Willingness to recommend or return, ratings of Likert scale (Nguyen Thi et al., 2002; Swan et al., 2003)	**Questionnaire survey** Two questions in Patient Judgments of Hospital Quality questionnaire (PJHQ) about intention of recommending the hospital or returning (Nguyen Thi et al., 2002)

The Role of Health Outcomes in Design Research

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In evidence-based design, defined as "the process of basing decisions about the built environment on credible research to achieve the best possible outcomes", measurable health outcomes are often perceived as the Holy Grail. If the link can be made between a specific design feature (such as room occupancy, hand washing location, flooring design, access to positive distraction, etc.) and a specific health outcome (such as measurable stress, anxiety, length of stay, medication, etc.), then a compelling case can be made for investing in design, especially in what is admittedly a tough economy. Health outcomes are defined as a change in the health status of an individual group or population which is attributable to a planned intervention or series of interventions. In the case of EBD, the planned intervention would be design. Ulrich and Gilpin outline the different kinds of health outcomes as follows:

1. Clinical outcomes are observable signs or symptoms related to patients' conditions (LOS, blood pressure, etc.)
2. Satisfaction and other reported outcomes (patient satisfaction, health-related quality of life, etc.)
3. Economic outcomes (cost of patient care, recruitment costs due to staff turnover, etc.)

Observable and/or reported signs of health can include the following outcomes:

1. Physiological outcomes: The body's response that is measured through appropriate instruments, such as blood pressure, heart rate, and salivary cortisol. Each needs a specific instrument to be measured and cannot be discerned by external observation alone.
2. Behavioral outcomes: Observable symptoms that can be measured through systematic observation of actions, gestures, facial expressions, and overall behavior. Tools for systematic behavioral observation are available. A trained observer must be onsite to measure behavioral outcomes.
3. Self-Reported outcomes: These are outcomes that are reported by the patients themselves using reliable and valid instruments that seek to understand a specific emotional, cognitive, or physical state of the patient. Examples are the STAI (State-Trait-Anxiety-Inventory), which asks a set of questions to determine a patient's state of anxiety, or standardized questionnaires for level of pain, overall quality of life, depression, etc. Typically, a psychometric test allows the measurement of psychological state. Other self-reports could be about overall satisfaction or surveys about the environment—these are not specifically aimed at measuring the health status of a patient and should not be confused with psychometric tests that can serve as a measure of a specific psychological state, although they can provide valuable insights on the impact of the environment and need to be tested for reliability and validity as well.

Table 1 provides some examples of typical metrics used for the perception of pain, stress and anxiety, which can have an impact on the patient experience and patient satisfaction.

Table 1: Type of Metrics

METRICS		Pain Perception	Stress	Anxiety
	Physiological	Patient Controlled Sedation[1]	Pupil Dilation[5]	Ability to Breathe and Respiration Rates[8]
	Physiological	Medication Rates & Strengths[2]	Heart Rate & Blood Pressure[3, 5, 6, 9]	Skin Conductance & Muscle Tension[9]
	Self-Reported	Profile of Mood States[3]	Perceived Stress Scale (PSS)	State Trait Anxiety Inventory (STAI)[7, 8]
	Self-Reported	McGill Pain Questionnaire3	Symptom Distress Scale (SDS)[7]	Revised Piper Fatigue Scale (PFS)[7]
	Self-Reported	Spielberger Questionnaire[4]	ZIPERS Survey[6]	Hospital Anxiety & Depression Scale (HADS)[10]
	Behavioral	Systematic Behavioral Observations[11]		

Oftentimes the use of physiological measures can be expensive and require expensive technical expertise. Self-report questionnaires are good alternatives, but if a patient is sick, they may not be able to respond to such instruments. Systematic behavioral observations can be a logistical challenge since they require a trained observer, and also because the presence of an observer may, in turn, change the behavior. In particular instances, observing and reporting direct outcomes with highly vulnerable patients may not be feasible.

In such cases, other metrics such as medication rates, which are indirect indicators of health status, can be used. The following is a case example from a study at a psychiatric mental health facility that used an existing metric (data routinely collected by the hospital) as a measure.

The study was conducted in a multi-purpose lounge of an acute care psychiatric unit. This unit addresses the needs of patients who are in crisis and require hospitalization to ensure their safety, or the safety of other persons, while their psychiatric issues are addressed. Patients are admitted through the emergency room of the hospital for observation and evaluation. Typical length of stay is three to five days, with a typical patient census of eight to 10 female patients ranging in age from 18 to 65 years of age. An art intervention was placed on a main focus wall in the lounge where patients gathered daily to eat, participate in art activities, watch television, or engage with their respective visitors. The objective of the study was to investigate the impact of art on patient agitation and anxiety. Three art conditions were identified based on a review of the literature (See Nanda, Eisen, Zadeh, and Owens for details on research design). Each art condition was mounted for a period of 16 to 19 days. The control condition of no art present was for a period of 21 days.

During the time that the art was displayed, nurses on the floor were asked to observe and document patient behavior. At the time of the study, nurses were not informed that PRN data would be analyzed. After the duration of art exposure, the hospital shared their records for the PRN medication dispensed to patients in the holding room during the 72-day period. The hospital also shared their patient census for each day so the PRN medications could be determined as a ratio of number of medications to number of people (see Table 2). The PRN medication is any medication that is given only 'when needed' for a specific condition. In this case, PRN medication refers to medication given as needed for visible signs of agitation or extreme anxiety. It is used to ensure that the patient does not become aggressive towards oneself or others. The most common PRN is a combination of an antipsychotic and a benzodiazepine (Haldol and Ativan). Different medications may be given if the patient is allergic to one of these medications or has been abusing the Ativan. A study conducted in 84 acute psychiatric wards and among 522 patients found that the primary reason for dispensing PRN medication was due to aggressive and agitated patient behavior prior to injection. Therefore, it is safe to say that PRN medication can be used as a valid measure to assess patient agitation and aggression.

Table 2: Total and Average PRN Incidents

	Abstract	Abstract Representational	Nature	Control
TOTAL	35	28	14	47
AVG/DAY	1.75	1.75	0.875	2.238095
AVG/PATIENT	0.284553	0.264151	0.132075	0.317568

Two statistical tests of Brown–Forsythe and Homogeneity of Variances were conducted to assess the normality and equality of variances, respectively, for the PRN/patient census data for each art condition and the control. Brown–Forsythe tests indicate data distribution is normal. T-tests were conducted to compare the ratio of PRN prescribed to patient census during each art condition with the control. Because equal variances were not assumed in the data, a Welch's correction was used for the unpaired t-tests. Figure 1 shows the scatter-plot from the unpaired t-test. T-tests were also conducted between each pair of art conditions, and the PRN/patient ratio was found to be significantly lower for the nature art condition compared to abstract art and no art, and marginally significant compared to the nature-abstract painting (details of findings and statistical analysis are available in the published journal paper).

Since PRN medications have a direct and calculable cost associated with them, this data was also retrieved from the hospital to analyze cost savings. The total cost per incident was shared by the hospital as $60.30 (details in Table 3). A key insight was that a PRN incident costs the hospital not just in medication costs, but also in terms of time of associated staff. Because dispensing the medication is typically associated with visible signs of anxiety and aggression, staff time includes not only the physician, RN, and pharmacist, but also a security personnel or psych tech who may be called upon to calm the patient. Of the $60.30, the hospital bills the patient $20.00. This implies each time there is a PRN incident, the hospital may go into loss. Based on this data shared by the hospital, the cost of PRN incidents avoided by installing art was projected annually for each case. The mean occupancy for the room was calculated as 6.62 based on the collected data. The annual average number of PRN incidents for the four cases was projected based on the sample data. The total annual incident costs before and after deduction of patient share was calculated. From that, we were able to deduce that the hospital could save close to $30,000 per year just from hanging the realistic nature image on the wall of this one patient lounge (see Nanda et al. for exact savings calculations).

Figure 1: PRN Medication/ Patient Ratio During Different Art Conditions

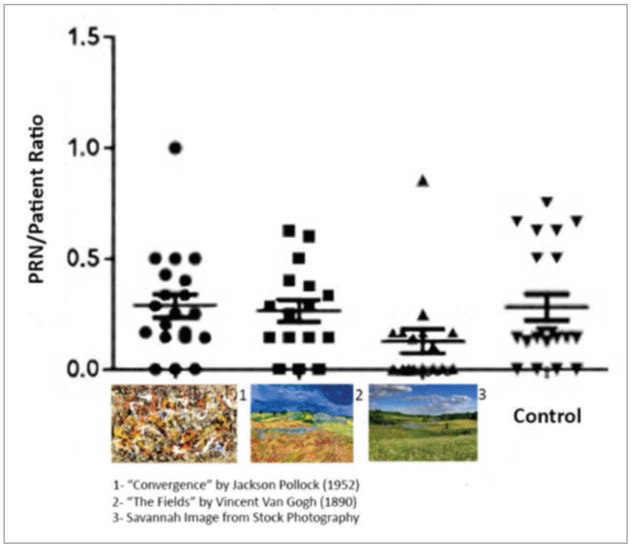

Table 3: Total Costs per Incident

Category	Costs
Medication	$ 3.30
RN, 20 minutes	$ 10.00
Doctor, 10 minutes	$ 20.00
Pharmacist	$ 10.00
Security	$ 10.00
Psych Tech	$ 7.00
Total	**$ 60.30**

(Source: Department of Psychiatry, EAMC)

The use of a simple metric like PRN data, which can be retrieved retrospectively, has two significant merits:

1. It is not expensive to collect, since it is an existing metric being used by the hospital, and
2. It has direct cost implications that can be computed to make a case at the organizational level.

It is also important to keep in mind that in the case of clinical outcomes, other confounds relating to the patient health may have to be carefully considered and controlled for. In this particular case, the homogeneity of the patient population (female mental health patients) was an advantage; however, lack of information about their specific psychiatric disorders, other medications, and lack of direct reports from the patients on their perception of the images can be considered limitations.

Note: Detailed findings from the study have been published in Nanda, U. Eisen, S., Zadeh, R., & Owen, D. (2011). Effect of visual art on patient anxiety and agitation in a mental health facility and implications for the business case. *Journal of Psychiatric and Mental Health Nursing.* We would also like to acknowledge Dr. Sarajane Eisen, who was a coinvestigator on the mental health study for her invaluable role in the project.

References

Ulrich, R.S., Simons, R.F., & Miles, M.A. (2003). Effects of environmental stimulations and television on blood donor stress. *Journal of Architectural and Planning Research,* 20(1), 38-47.

Schneider, S.M., Ellis, M., Coombs, W.T., Shonkwiler, E.L., & Folsom, L.C. (2003). Virtual reality intervention for older women with breast cancer. *Cyberpsychol Behav,* 6(3), 301-307.

Diette, G.B., Lechtzin, N., Haponik, E., Devrotes, A., & Rubin, H.R. (2003). Distraction Therapy with Nature Sights and Sounds Reduces Pain During Flexible Bronchoscopy: A Complementary Approach to Routine Analgesia. *Chest,* 123, 941-948.

Ulrich, R.S., Simons, R.F., Losito, B.D., Fiorito, E., Miles, M.A., & Zelson, M. (1991). Stress Recovery during Exposure to Natural and Urban Environments. *Journal of Envronmental Psychology,* 11, 201-230.

Oyama, H., Kaneda, M., Katsumata, N., Akechi, T., & Ohsuga, M. (2000). Using the Bedside Wellness System During Chemotherapy Decreases Fatigue and Emesis in Cancer Patients. *Journal of Medical Symptoms,* 24(3), 173-182.

Nanda, U., Chanaud, C., Nelson, M., Zhu, X., Bajema, R., & Jansen, B. (2012). Impact of visual art on patient behavior in the emergency department. *Journal of Emergency Medicine*, 43(1), 172-181.

Stewart, D., Robson, D., Chaplin, R., Quirk, A., & Bowers, L. (2012). Behavioral antecedents to pro re nata psychotropic medication administration on acute psychiatric wards. *International Journal of Mental Health Nursing*, (online, August 1st).

Center for Health Design. (2012). Retrieved from http://www.healthdesign.org/edac/about

Frommer, M., Rubin, g., & Lyle, D. (1992). The NSW Health Outcomes Program. *NSW Public Health Bulletin* 3: 136-137.

Ulrich, R. S. and L. Gilpin (2003). Healing arts: Nutrition for the soul. *Putting patients first: Designing and practicing patient-centered care*. S. B. Frampton, L. Gilpin and P. Charmel. San Francisco, Jossey-Bass: 117-146.

Nanda, U. Eisen, S., Zadeh, R., & Owen, D. (2011). Effect of visual art on patient anxiety and agitation in a mental health facility and implications for the business case. *Journal of Psychiatric and Mental Health Nursing*, 18(5), 386-393.

Measuring the 'PLAN': Possibilities of Space Syntax in Healthcare Environments Research

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Abridged version of Haq, S. and Y. Luo (2012). "Space Syntax in Health-Care Facilities Research: A Review." *Health Environments Research & Design* 5(4).

CONTEXT

In architecture, the term 'configuration' is widely used to indicate how spaces are arranged and connected to one another. Sometimes we speak about configuration as if we see with x-ray eyes from the sky, and use words such as 'radial', 'double-corridor, 'single corridor', etc. or describe overall shapes such as 'rectangular', 'circular', 'H-shaped', and so on. Yet, as peripatetic users of buildings, we experience spaces in a diachronic manner, moving from one to the other and getting new visual information with every change of position. Thus, the connections between spaces become one foundation for understanding the larger layout, regardless of its aerial/external shape.

Space Syntax deals with layout 'configuration' based on connections (Hillier, Leaman, et al. 1978; Hillier and Hanson, 1984). It has developed a theory and a method to analyze layouts according to that theory. The latter, being more mathematical and technological, led to the development of various computerized software. This allowed use by other researchers interested in quantifying layouts for use as predictor variables. Since the late 1990s, Space Syntax has been increasingly used to study healthcare facilities, making it relevant to healthcare researchers.

VARIABLES OF INTEREST

Space Syntax measures the overall plan of a setting and unit spaces within it. These spaces can be socially described, such as 'patient rooms', 'corridors', etc., or precisely defined, such as 'longest uninterrupted visibility lines', or a small area of convenient dimensions, i.e., a small tile on the floor. Variables produced for each unit are called 'Integration', 'Connectivity', etc. Variables applicable to the overall layout are 'Intelligibility', 'mean integration', etc.

TOOL DEVELOPMENT AND USE

An example is a good way to introduce Space Syntax. Assume that each corridor in the plan shown in Figure 1b is an individual space identified by numbers 1 through 24. The entrance is at X, leading to corridor # 1. This corridor (i.e., # 1) connects directly to corridor numbers 24, 4, 3, and 2. Each of these corridors is, in turn, connected to other corridors. For example, corridor #4 is connected to corridor numbers 10, 1, and 5; corridor #10 is connected to numbers 4, 16, 11, and 14; and so on. This relationship of connections is graphically illustrated as a system of nodes and links in Figures 2 a, b, and c for corridor numbers 1, 4, and 10 respectively. The number of direct connections to other spaces is called 'connectivity'. Thus the connectivity values of corridor numbers 1, 4, and 10 are 4, 3, and 4, respectively. After considering immediate connections, we see that each corridor is progressively connected to far-away corridors through a set of secondary, tertiary, and sequentially deeper corridors. For example, corridor #1 is connected to corridor #10 through corridor #4. Corridor #10 is directly connected to corridor numbers 4, 16, 11, and 14; has secondary connections to corridor numbers 1, 5, 15, 12, and 13; tertiary connections to corridor numbers 24, 2, 3, 8, 6, 17, and 21, and so on, until all the other 23 corridors are connected. All the connections encountered from corridor #1 and #10 are indicated in Figures 3a and 3b as a graph. This also shows that each corridor has a different relationship to all other corridors in the spatial system. If we consider any corridor, it will be directly connected to certain corridors, and at varying depths to all others.

Figure 3a shows that corridor #1 needs seven steps to connect to all 23 other corridors, while corridor #10 only needs five depths (Figure 3b). Corridor # 1 therefore has a 'deep' relationship to all corridors, while corridor #10 has a comparatively 'shallow' relationship. If we flip the relationship, it means that it will be easier to come to #10 from all other corridors, on an average, when compared to #1. In a similar manner, considering the relationship of all corridors to all other corridors in the system, we can discover which one has the shallowest relationship. This is expressed by a numerical concept, 'integration'. Syntax has a mathematical equation to determine this value. It considers both the number of corridors one is connected to, as well as the step-depth of all those connections (Hiller and Hanson, 1984). A corridor with high integration is, on an average, closely connected to all other corridors in a given layout. Conversely, a corridor that is distant from all other corridors, on average, is called 'segregated'. Space Syntax software produces a table with values of each unit space, and a color-coded diagram matching the plan drawing indicating the distribution of those values (see Figure 4.)

The preceding description is (very) simplified. The unit spaces considered are corridors. Actually, Syntax is very particular about identifying unit spaces, and most predominant space in the literature is 'axial lines' (Hillier and Hanson, 1984). These are the set of the longest and fewest lines that can cover all convex spaces in any layout. An axial line analysis of a hypothetical MSU is shown in Figure 5. The top 10 percent of integrated lines, called the 'integration core', is indicated by the thicker lines. The distribution of the 'integration core' in the plan is of special interest to designers.

A finer unit is a 'tile'. Hypothetically, a set of square 'tiles' of a convenient dimension can be laid on any plan. Walls and furniture, wherever they occur, break up the relationship of tiles to one another. This system can then be examined to uncover each tile's relationship to adjacent tiles, and sequentially to distant tiles, in the same manner as the corridors were examined earlier. Thus we can calculate the same values of each tile (see Figure 6). Theoretically, when the tiles are laid at eye level and only walls break up the inter-tile relationships, then its analysis will represent the 'visibility' structure of a layout. When placed at knee level, i.e., when furniture is considered, the analysis will display the 'accessibility' structure.

We mentioned earlier that Space Syntax also measures entire layouts or plan drawings. The first measure is 'Intelligibility', which is the correlation (r-value) between the 'connectivity' and 'integration' values of all spaces in the layout. If this value is high, then presumably a good sense of global connections will be perceivable from unit spaces. Additionally, average values of units, such as 'mean integration', 'average mean depth' etc., are also used.

FINDINGS AND CONCLUSIONS

Space Syntax has been used to study health-care buildings since the 1990s, and its use has increased dramatically in the last decade (see Table 1). Highlights of some research are given below:

- A series of studies inside four hospital buildings in the U.S., three in China, two in Taiwan, and in one virtual reality setting have demonstrated the following: (1) exploring visitors and those who are lost tend to use more integrated corridors, (2) the Syntax values of an entry space have a role in wayfinding success, and (3) more connected corridors feature more prominently in human cognitive maps. (Peponis, Zimring, et al., 1990; Haq, 2003; Haq and Girotto, 2003; Haq and Zimring, 2003; Pramanik, Haq, et al., 2006; Haq, Hill, et al., 2009; Lu and Bozovic-Stamenovic, 2009; Tzeng and Huang, 2009).

- Another set of studies indicate that nurses who have assignments in rooms corresponding to higher Syntax integration values will enter them more frequently and spend more time there, thus potentially increasing care quality (Choudhary, Bafna, et al., 2009; Hendrich, Chow, et al., 2009; Heo, Choudhary, et al., 2009).
- Nurses constantly move from one point to another. However, they tend to locate themselves for work and interaction in areas that provide higher visibility to patient rooms. Visibility in this case was measured using Space Syntax techniques (Lu, Peponis, et al., 2009; Lu, 2010; Lu and Zimring, 2010).
- Another study suggests that patients prefer ward beds in lower integrated areas for privacy, but feel safer when they are in more integrated locations, presumably because this makes them more visible to nurses (Alalouch and Aspinall, 2007; Alalouch, Aspinall, et al., 2009).
- Finally, in old people's homes in England, more mean integration of environments was associated with a larger proportion of residents being active and being more engaged (Hanson and Zako, 2005).

Table 1: Research in healthcare that has used Space Syntax variables. Articles by publication year.

	Before 2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Journal Articles	2			2				1		5	5
Conference Proceedings	1					4				2	2
Total	3			2		4				7	7

Figure 1: 'City Hospital' (a) Ground Floor Plan, (b) Public corridor system showing connections between corridors

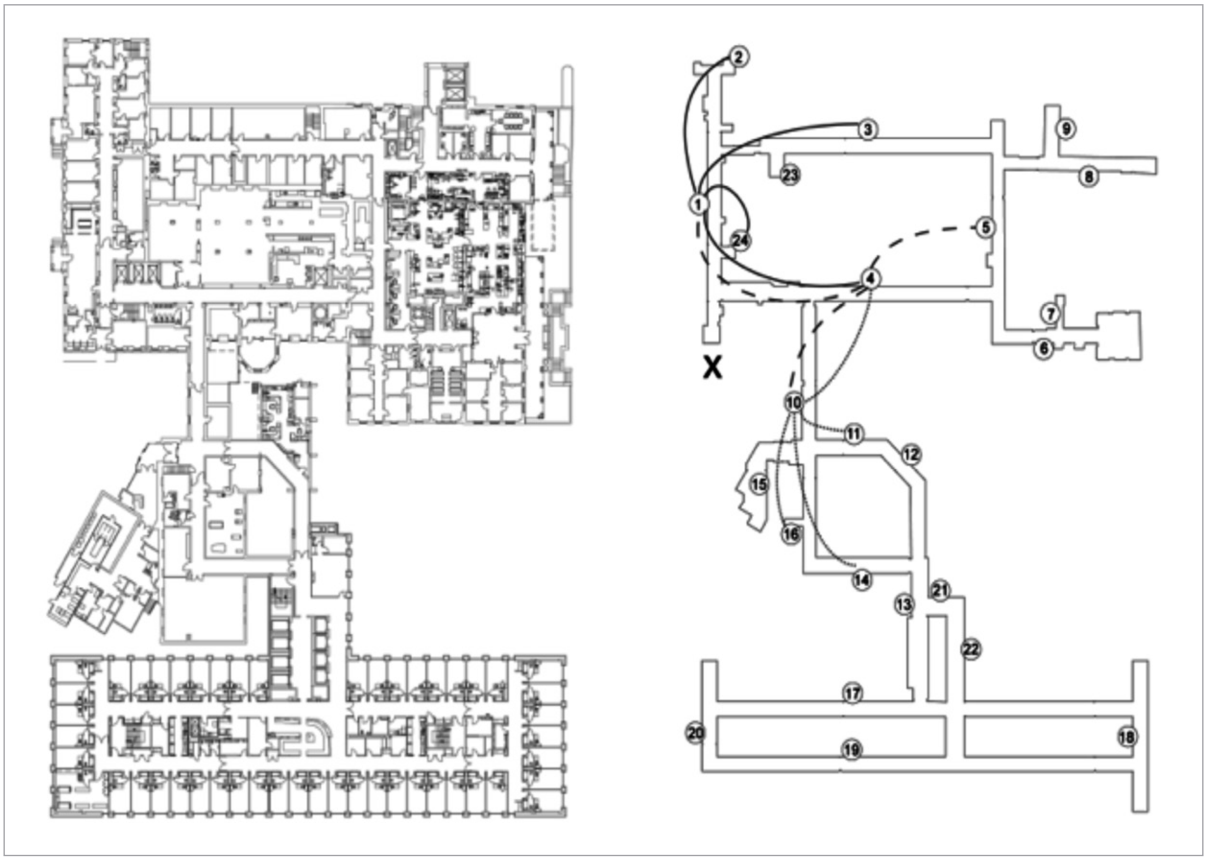


Figure 2: Relationships to ADJACENT corridors from (a) corridor #1, (b) corridor #4, and (c) corridor #10

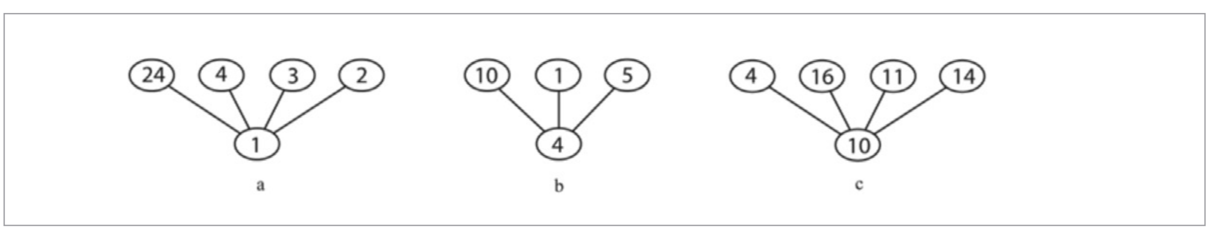


Figure 3: Relationships to ALL other corridors from (a) corridor #1, and (b) corridor #10. These are also called justified graphs.

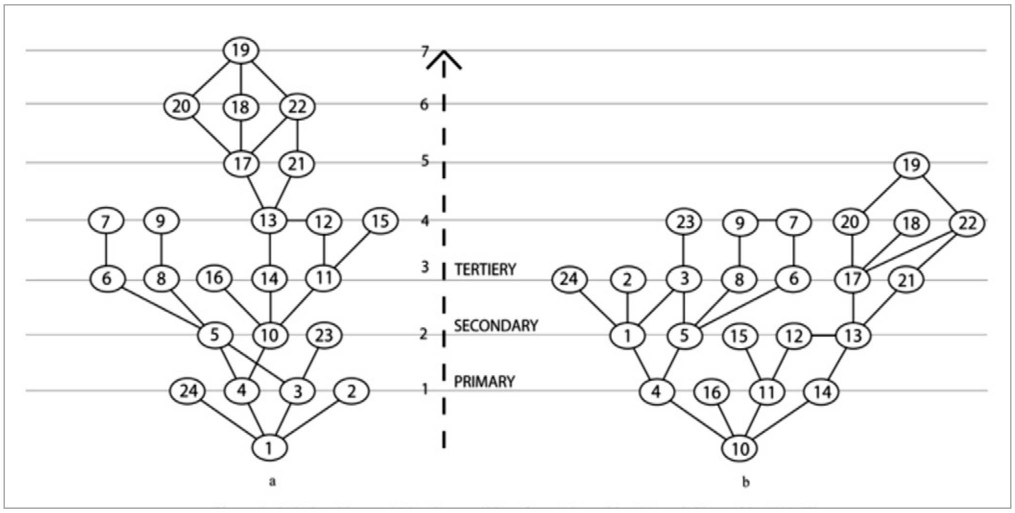


Figure 4: Space Syntax (axial) analysis showing integration-n of the public corridors of 'City Hospital'. Warmer colors are more integrated.

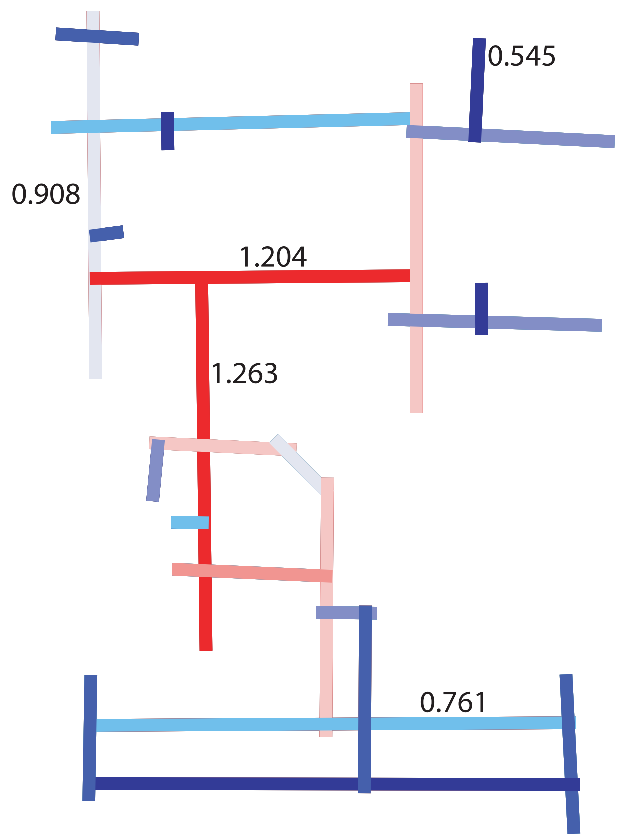
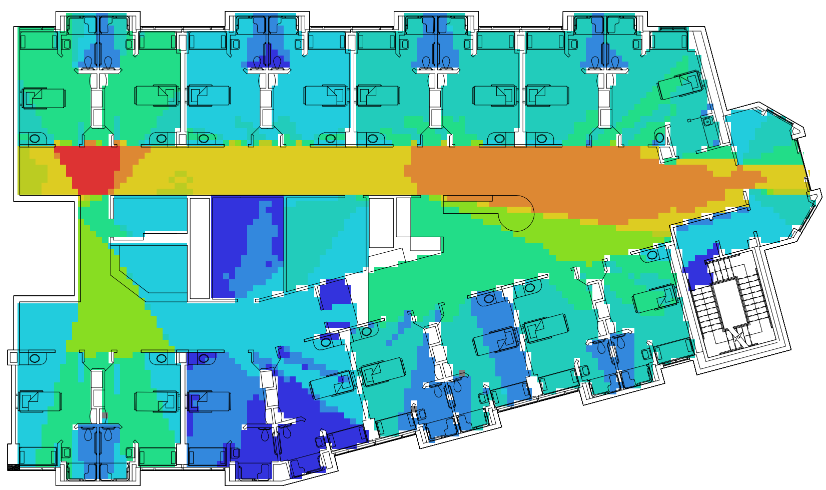


Figure 5: Integration-n analysis in a hypothetical MSU. Higher integration values are shown by darker lines, and thicker lines indicate the 'integration core'

Figure 6: Integration analysis of convex spaces of hypothetical MSU. Higher integration values are shown by warmer colors.



References

Alalouch, C. and P. Aspinall (2007). Spatial attributes of hospital multi-bed wards and preferences for privacy. *Facilities* 25(9/10): 18.

Alalouch, C., P. Aspinall, et al. (2009). On locational preferences for privacy in hospital wards. *Facilities* 27(3/4, 2009).

Choudhary, R., S. Bafna, et al. (2009). A Predictive Model for Computing the Influence of Space Layouts on Nurses Movement in Hospital Units. *Journal of Building Performance Simulation* 3(3): 171-184.

Hanson, J. and R. Zako (2005). *Configuration and Design in Caring Environments: Syntax and quality of life in a sample of residential care homes for older people.* 5th Space Syntax International Conference, Delft.

Haq, S. (2003). Investigating the Syntax Line: Configurational Properties and Cognitive Correlates. *Environment and Planning B: Planning and Design*, Pion Publications, London, 30(6)(November,): 841-863.

Haq, S. and S. Girotto (2003). *Ability and Intelligibility: Wayfinding and Environmental Cognition in the Designed Environment*. Space Syntax 4th International Symposium. J. Hanson. London, The Bartlett School of Graduate Studies, University College London. 2: 68.61-68.20.

Haq, S., G. Hill, et al. (2009). Topological configuration in wayfinding and spatial cognition: a study with real and virtual buildings for design relevance. ARCC 2009 - *Leadership in Architectural Research, between academia and the profession.* University of San Antonio, TX: 171-178.

Haq, S. and C. Zimring (2003). Just down the road a piece: The development of topological knowledge of Building Layouts. *Environment and Behavior.* 35: 132-160.

Hendrich, A., M. P. Chow, et al. (2009). Unit-Related Factors That Affect Nursing Time with Patients: Spatial Analysis of the Time and Motion Study. *Health Environments Research & Design Journal* 2(2): 17.

Heo, Y., R. Choudhary, et al. (2009). *A Modeling Approach for Estimating the Impact of Spatial Configuration on Nurses' Movement.* The 7th International Space Syntax Symposium.

Hillier, B. and J. Hanson (1984). *The Social Logic of Space.* Cambridge, Cambridge University Press.

Hillier, B., A. Leaman, et al. (1978). Space Syntax. *Social Organization and Settlement: Contributions from Anthropology, Archeology and Geography.* C. H. a. M. S. David Green. Oxford, England, British Archeological Reports. 47: 343-381.

Lu, Y. (2010). Measuring the Structure of Visual Fields in Nursing Units. *Health Environments Research & Design* 3(2).

Lu, Y. and R. Bozovic-Stamenovic (2009). Cultural Perspective of wayfinding Behavior: Exploring the Socio-Spatiasl Variable in Three Chineese Hospitals Case Studies. *International Journal of Architectural Research* 3(2): 22-34.

Lu, Y., J. Peponis, et al. (2009). *Targeted Visibility Analysis in Buildings: Correlating Targeted Visibility Analysis with Distribution of People and Their Interactions within an Intensive Care Unit.* 7th International Space Syntax Symposium, Stockholm.

Lu, Y. and C. Zimring (2010). *Developing a visibility index for nursing units.* 41st Conference of the Environmental Design Research Association.

Peponis, J., C. Zimring, et al. (1990). Finding the building in wayfinding. *Environment and Behavior 22*, no.5: 555-590.

Pramanik, A., S. Haq, et al. (2006). The use of virtual environment as a tool for wayfinding research in the built environment: A comparison of virtual and real environments. *Interior Design Educator Council International Conference*. Scottsdale, AZ.

Tzeng, S.-Y. and J.-S. Huang (2009). "Spatial Forms and Signage in Wayfinding Decision Points for Hospital Outpatient Services." *Journal of Asian Architecture and Building engineering* Nov: 453-460.

Correlating Spatial Metrics of Nurse Station Typology with Nurses' Communication and Co-Awareness in an Intensive Care Unit

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CONTEXT

Previous studies tend to describe nurse station typologies with oversimplified categorizations, i.e., centralized, decentralized, and hybrid. There is a lack of rigorous analysis of the spatial qualities of nurse station typologies and the impacts on nurses' communication. Thus, this study addresses two key questions:

1. Can we propose some spatial measures to provide more accurate descriptions of nurse station typologies?
2. Can the proposed measures explain behavioral differences, such as the frequency of nurses' interaction and the awareness of peers' work in hospitals?

VARIABLES OF INTEREST

Visibility	Mechanism	Outcomes
Increased staff to staff visibility • Integration • Team-base distance • Peer distance	**Increased communication and care coordination**	**Improved work efficiency** • Communication rate • Awareness of patients' condition • Awareness of peers

In this study, we propose integration, team-distance, and peer-distance as key metrics based on the space syntax theory to examine nurse station typologies as inter-connected spatial systems.

TOOL DEVELOPMENT AND USE

Many case studies in Space Syntax have linked the building configuration to organizational behaviors, including movement, physical co-presence, co-awareness, and unplanned social interactions (Grajewski, 1993; Penn, Desyllas & Vaughan, 1999; Peponis et al., 2007; Rashid, Kampschroer, Wineman & Zimring, 2006; Rashid & Zimring, 2003; Sailer, Budgen, Lonsdale, Turner & Penn, 2009; Sailer & Penn, 2007; Serrato & Wineman, 1999). They suggested that layout attributes such as visibility and accessibility were important factors in deliberate users' movement, face-to-face communication, co-awareness, and organizational performance.

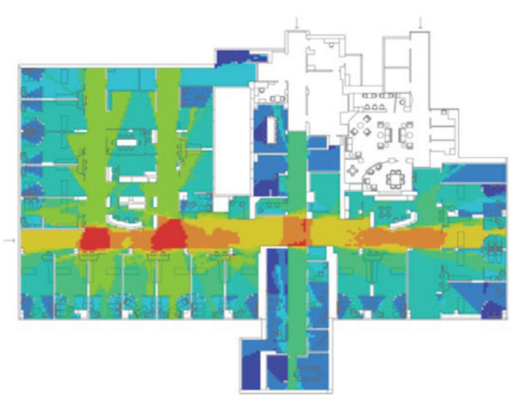
However, most existing space syntax studies are done in weak programmed settings like offices, museums, and labs. The application of space syntax theory in more strong programmed spaces such as hospital environments is comparatively new. In a recent study, Hendrich et al. (2009) use space syntax methods to re-analyze existing time and motion data in nursing units. They reveal that the nurse assignments with higher integration/centrality can lead to greater frequency of nurses' visits to patient rooms and the nurse station. Trzpuc and Martin (2010) analyzed three nursing unit plans, a centralized station with four pods, a centralized station with six pods, and a hybrid station, based on two space syntax concepts, visibility and connectivity. However, their analysis stayed focused on the qualitative descriptions of spatial propensity and failed to establish the correlation between space and nurses' frequency of communication and perceived social support. In this study, we extend the examination of the relationship between spatial layout and spatial behaviors such as face-to-face communication and co-awareness to hospital settings. More importantly, we propose a more systematic approach to evaluating the spatial configuration of nursing units with quantitative spatial measures. The validity of the spatial measures in predicting nurses' communication and learning is tested through a comparative case study of two wings of the Neurology Intensive Care Unit (2D-ICU) at Emory University Hospital in Atlanta in the United States.

We used the program Depthmap to conduct spatial analysis and describe the patterns of visibility. In addition to *Integration* as a generic measure of visibility (Figure 1a), we developed two relational metrics, *Team-base Distance (TD)* and *Peer Distance (PD),* to describe specific spatial relationships between nurse station components. These two values are based on the concept of *step depth,* which is a relational value and measures the number of turns (plus one) that needed to be traversed from the current location to see any other location within the plan (Turner, 2004). Every space that is directly visible from the selected origin is counted as one step away from that origin. In other words, *step depth* can represent the degree of accessibility between points of interest. For *TD,* we set one central nurse station as the origin, and calculated the *Step Depth* from the origin to each alcove in the same sub-unit. This value demonstrated how the nurse in each alcove perceived her distance from her immediate team-base. In addition, we proposed *PD* as another metric to depict the spatial relationship among alcoves. It was the average value of the *Step Depth* from the selected alcove to all other alcoves (Figure 1b).

We further differentiated the impact of space on the sense of community in the immediate sub-unit and the overall 2D unit with two values, *Local PD* and *Global PD.* The former value was calculated based on the values within the sub-unit, while the latter was based on the whole unit. For instance, the *Local PD* of W1 was the average value of its step depth to all seven peer alcoves in the 2D-W. The *Global PD* of W1 was the average value of its step depth to all ten peer alcoves in the 2D ICU.

As physical proximity is important for communication, we also include the measure of *Metric Step Depth,* which is a weighted version of the Step Depth, considering the metric distance from one location to another (Turner, 2004). Both the *Visual* and *Metric Step Depth* values were calculated for all measures. In short, the *TD* represented the visual proximity to team work, and the *PD* represented the visual proximity to peer alcoves. Both values might contribute to nurses' sense of community.

Figure 1a (left): 2D ICU East & West Wing Visual Integration Graph
Figure 1b (right): Visual Step Depth Graph, with W3 as the origin
(The value goes from low to high following the color changing from blue to red.)

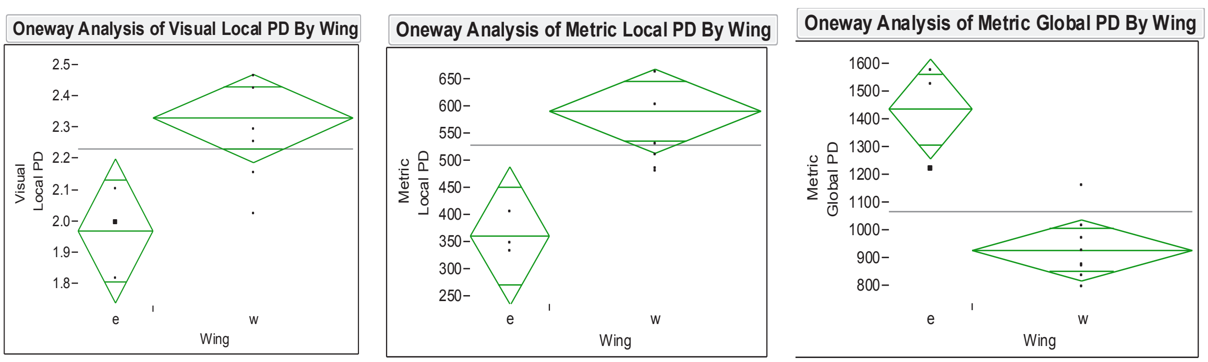


Behavior data is collected through behavior mapping and "co-awareness mapping" to test the validity of the proposed spatial metrics. In total, 56 sets of behavior mapping and 3,986 events have been collected. A "co-awareness network mapping" is also conducted to find out whether the spatial qualities of nurses' assigned alcoves affect their awareness of surrounding environment and peers. The awareness level is a good indicator of the sense of community and social support, since nurses have to be continually aware of what peers are doing to provide timely help. In this study, we asked the nurse to map in the plan the rooms which she is aware of the status, as well as those peers whose assigned alcoves are known to her.

RESULTS

Although 2D-W and 2D-E are both based on hybrid nurse station typology, they demonstrate quite different spatial characters in terms of visibility integration and the inter-relationship among the central station and peer alcoves. The t-tests show that the differences in *Visual Local PD, Metric Local PD,* and *Metric Global PD* are statistically significant (Figures 2a, 2b, and 2c).

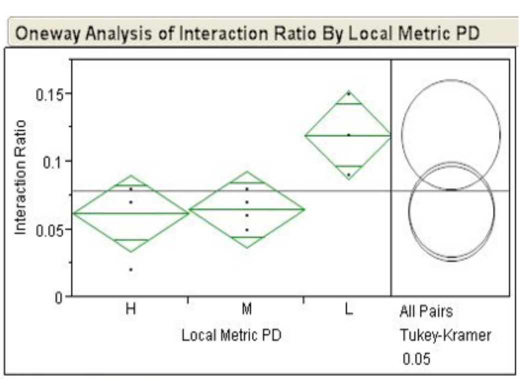
Figure 2a (left): the t-test of *Visual Local PD* by wing; Figure 2b (middle): the t-test of *Metric Local PD* by wing; Figure 2c (right): the t-test of *Metric Global PD* by wing.



EFFECTIVENESS OF THE METRICS IN PREDICTING BEHAVIORAL DIFFERENCES

To test the impacts of the spatial metrics on interactions, we categorize alcoves as High, Medium, and Low groups based on their *PD* values and correlate them to interaction ratios. The Tukey's test reveals that nurses assigned in alcoves with lower *Metric Local PD* have significantly higher interaction ratios (p=0.036 comparing to the High group and p=0.0438 comparing to the Medium group) (Figure 3).

Figure 3: Tukey's HSD all-pair comparison of interaction ratio between the High, Medium, and Low *Metric Local PD* value groups.



The overall number of rooms that a nurse is aware of patient status is positively correlated to the global integration value of her alcove (R=0.715, p=0.004). The *Room Awareness Ratio* is also negatively correlated to the *Visual* and *Metric Local PD* (R=-.604, p=0.049 and R=-.644, p=.033 respectively). The *Peer Awareness* value is found to be negatively correlated to the *Metric Global PD* of the assigned alcove (R=-.698, p=.017). The correlations hold true when we control nurses' length of work experiences.

FINDINGS AND CONCLUSIONS

The spatial metrics demonstrate strong correlation to nurses' distribution, interaction, and co-awareness. Nurses assigned in alcoves with lower *Metric Local Peer Distance* have significantly higher interaction ratios. The *Metric Peer Distance* of nurses' alcoves shows a strong negative correlation to nurses' awareness of other patients' condition and the peers' location.

The spatial metrics provide a more precise way of documenting and analyzing nurse station designs. They can be applied as a standard tool to build comparable literature in the future and help architects make more informed design decisions. Instead of using the traditional centralized, decentralized, and hybrid layout to describe nurse station typology, we propose to classify nurse station designs based on the spatial relationship between different components using the proposed spatial metrics.

Note: An earlier format of this paper has been published in *World Health Design* (July), 2011.

References

Cai, H., & Zimring, C. (2011). Stay Connected in Decentralized Nurse Station: The Impact of Nurse Station Typology on Nurses' Informal communication and Learning. *World Health Design(July),* 60-67.

Grajewski, T. (1993). The SAS head office:spatial configuration and interaction patterns. *Nordic Journal of Architectural Research, 2,* 63-74.

Hendrich, A., Chow, M., Bafna, S., Choudhary, R., Heo, Y., & Skierczynski, B. (2009). Unit-related factors that affect nursing time with patients: spatial analysis of the time and motion study. *HERD, 2*(2), 5.

Penn, A., Desyllas, J., & Vaughan, L. (1999). The space of innovation: interaction and communication in the work environment. *Environment and Planning B: Planning and Design, 26,* 193-218.

Peponis, Bafna, Bajaj, Bromberg, Congdon, Rashid, . . . Zimring. (2007). Designing space to support knowledge work. *Environment and Behavior, 39*(6), 815-840.

Rashid, M., Kampschroer, K., Wineman, J., & Zimring, C. (2006). Spatial layout and face-to-face interaction in offices--a study of the mechanisms of spatial effects on face-to-face interaction. *Environment and Planning B: Planning and Design, 33*(6), 825-844.

Rashid, M., & Zimring, C. (2003). *Organizational constructs and the structure of space: A comparative study of office layouts.* Paper presented at the the 4th International Space Syntax Symposium, , UCL, London.

Sailer, K., Budgen, A., Lonsdale, N., Turner, A., & Penn, A. (2009). *Comparative studies of offices pre and post—how changing spatial configurations affect organisational behaviours.* Paper presented at the Proceedings of the 7th International Space Syntax Symposium, Stockholm, KTH.

Sailer, K., & Penn, A. (2007). *The performance of space–exploring social and spatial phenomena of interaction patterns in an organisation.* Paper presented at the International Architecture and Phenomenology Conference, Haifa.

Serrato, M., & Wineman, J. (1999). *Spatial and communication patterns in research and development facilities.* Paper presented at the the Second International Space Syntax Symposium, Brazilia.

Trzpuc, S., & Martin, C. (2010). Application of space syntax theory in the study of medical-surgical nursing units in urban hospitals. *HERD, 4*(1), 34.

Turner, A. (2004). Depthmap 4: A researcher's handbook: Citeseer.

Behavioral Observations for Simulations and Mock-Ups

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INTRODUCTION

Modeling is no longer solely about building miniature planes, trains, and automobiles. It has expanded into the realm of the built environment as well. Design researchers use both physical mock-ups (models) and computer simulations to test the validity of design solutions (Peavey et al., 2012). Simulation and mock-up models are growing in importance within built environment research. This is because of their benefits towards securing key stakeholder commitments, streamlining design decisions, and integrating emerging technologies and processes into facility design (Peavey et al., 2012).

Both simulations and mock-ups are simplified versions of real-world systems that rely on input variables for their accuracy. Behavioral observations offer critical input variables for both modeling types. These observations provide the raw data used to test the validity of design assumptions and models. Research, through behavioral observation, can be implemented throughout the design process, including defining the market for a new project, building a statement of need, defining a project philosophy of use, and evaluating and measuring the success of a project (Augustine & Coleman, 2011). This paper will provide an overview of the different types of behavioral observations, their influences on modeling outcomes, and how they can be successfully integrated with simulations and mock-ups.

TYPES OF BEHAVIOR OBSERVATION

Behavior observation is the process of observing behaviors and interactions within a given environment to better understand the topic one is examining. The three types of behavioral observation that will be discussed in this paper are naturalistic (casual), controlled (systematic), and participant observations. During naturalistic observations, data is collected by unobtrusively observing subjects in their natural environment. The researcher is not to interfere with the observed subjects while recording their behavior. These recordings are generally informal and do not allow the observer a structured degree of control over the environment. Similar to this type of behavioral observation is the work of Jane Goodall with chimpanzees in Tanzania. Because of a lack of control, naturalistic observations for design research are generally done in the early stages of research projects, before moving onto controlled observations (Sommer & Sommer, 1997).

Related to naturalistic observations are participant observations. These observations are qualitative in nature and allow the observer to become a part of the events being studied (Sommer & Sommer, 1997). This methodology is popular with industrial design consultancies, such as those consulting for Mercedes, Xerox, or Macintosh. This is because of the observations' ability to develop empathy in the researcher towards the subjects and topics being studied. The aim is to develop an understanding of the research topic from the observed subject's perspective; for this reason it is referred to as an interpretive research methodology.

Participant observation allows flexibility for a researcher to study a topic without deciding in advance what is or is not important. This flexibility also allows a researcher the opportunity to test and refine hypotheses and personal perceptions through his or her involvement within the observed group. Limitations of participant observation include the scope, scale, and timeframe of the study. Interpretation of the research results is also a concern if the researcher's understanding varies from those of the observed subjects.

The most commonly used observation technique in environmental design research is the controlled observation. Controlled observations offer the observer a greater degree of systematization over how observations are recorded within the environment. These observations have their recordings pre-coded and structured so that the observational tools can be applied consistently (Sommer & Sommer, 1997).

These pre-coded recordings allow one to prioritize specific variables of interest. Examples of these codings include categories of participants (i.e., patients, visitors, nurses, doctors), activities (i.e., charting, interacting, eating), and position (i.e., standing, sitting) (Watkins et. al., 2011). Tools used to record behaviors in this setting include paper, handheld technologies, and computer-based tablets.

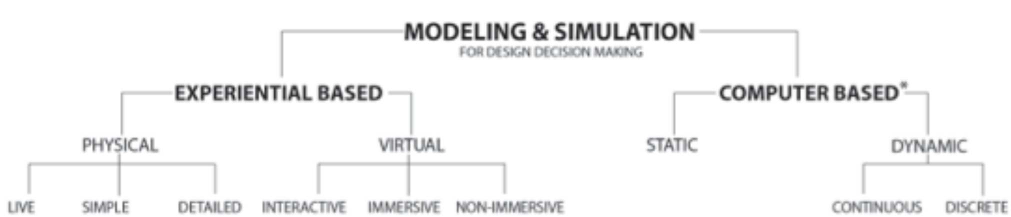
Tablets are becoming a popular recording tool, as they allow the observer to time-stamp observations at a specific position on a floor plan (Watkins et. al., 2011). With the use of tables, several values and complex codings can be automated. Relative to traditional methods, one can quickly and easily link observational data with spatial values. Doing this allows the subjects' location to be correlated with their observed activities, potentially providing additional insight for future models (Watkins et. al., 2011). For example, the spatial integration of environmental and behavioral analysis is commonly referred to as spatial syntax. Spatial syntax techniques are used to correlate an environmental layout to social and behavioral interactions that occur within the layout. Integrating spatial syntax and behavioral observation with tablet capabilities allows a researcher to look directly at the impact of spatial layout on spatial usage without laborious data entry. The research can expediently reveal hidden relationships that may not be obvious through typical observation methods.

INTEGRATING WITH SIMULATIONS AND MOCK-UPS

Researchers use simulations and mock-ups to test new concepts and to validate hypotheses before implementing them on a live project (Peavey & Watkins, 2012). Drivers for pursuing these models include showing how design solutions improve outcomes and building performance, streamlining the design decision-making process, securing stakeholder buy-in, and using them as educational training tools (Peavey & Watkins, 2012).

There are two types of computer-based simulation models used to observe the systems within an environment (Peavey et. al., 2011). These are dynamic and static simulations. Static simulations are usually performed with spreadsheet software to examine a single point in time and to create benchmarks for forecasting and programming (Peavey & Watkins, 2012). Dynamic simulations are often animated, using specialized software to examine the interrelated parts of a system and potential process improvements at a macro-scale (Watkins and Peavey, 2012). The results of a computer-based simulation is only as accurate as the accuracy of the data input into the program. Figure 1 shares a useful hierarchy of simulation and modeling types.

Figure 1: Simplified diagram of the simulation and modeling types, which are discussed here as a sample of the options available for informing design decision-making.



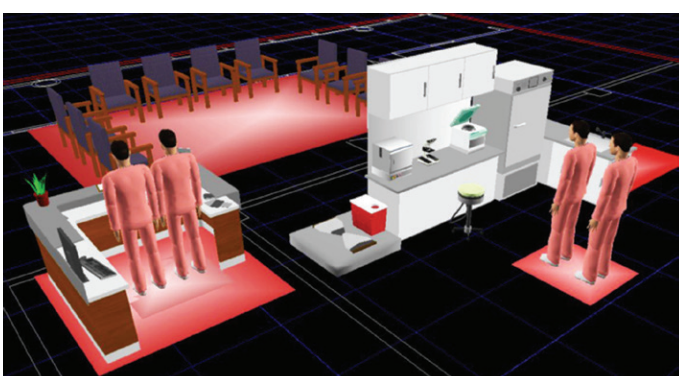
For example, simulating healthcare facilities requires that accurate assumptions about patient volumes, procedure times, clinician schedules, and travel distances be collected for input (Peavey and Watkins, 2012). These behavioral observations provide the data required to create accurate models that reflect the healthcare environment's effect on operations, staff needs, and other outcome metrics.

In contrast to computer-based simulations, mock-ups allow researchers to focus on the personal experience of the environment being observed (Peavey et. al., 2011). These experience-based models can be accomplished through either physical constructions or through a virtual environment. Physical mock-ups can be accomplished through various phases. Figure 2 illustrates a physical mock-up and its assessment. These include simple mock-ups using tape and foam core, detailed mock-ups with more environmental interaction, and live mock-ups which are integrated into the surrounding environments (Watkins et. al., 2012).

Figure 2: Clinical staff responding to questionnaires on a physical mock-up of a patient room in University Medical Center at Princeton.

Virtual mock-ups utilize computer visualizations tools such as Cave Automatic Virtual Environments (CAVEs) (Peavey, 2012; Dunston et. al., 2007), 3-D visualization facilities (Peavey, 2012), and building information models (BIM) exported into a virtual environment (Peavey, 2012; DiLorenzo, 2011). Figure 3 illustrates a dynamic simulation that utilizes a virtual mock-up.

Figure 3: 3D dynamic simulation of a laboratory, reception, and waiting area.



Behavioral observations for mock-ups differ from those used for computer simulations. Observations generally occur during or after the mock-up is built to test assumptions. For example, care simulations often take place within mock-ups of various iterations of a patient room; here, controlled observation can be used to measure how differing room options impact care delivery. This process is extremely valuable for the researcher to verify the impact of design on outcome measures (Peavey and Watkins, 2012). Figure 4 illustrates the use of an iPad tool to perform behavioral observations. Figure 5 illustrates what the behavioral observation data looks like as it is mapped to an inpatient unit plan with spatial syntax values specific to unit visibility and circulation patterns.

Figure 4: Research assistant taking behavior observations on HOK's tablet-based observation tool.

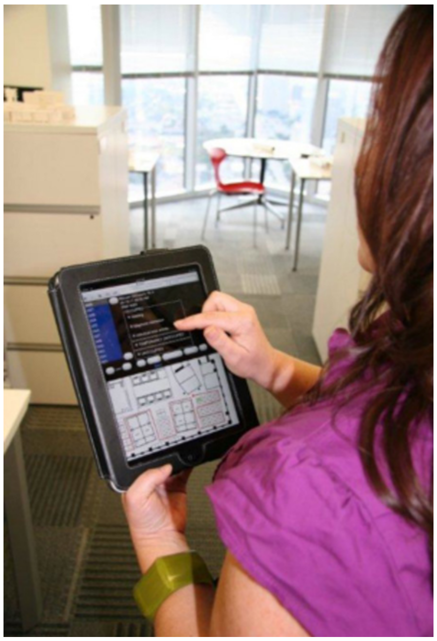
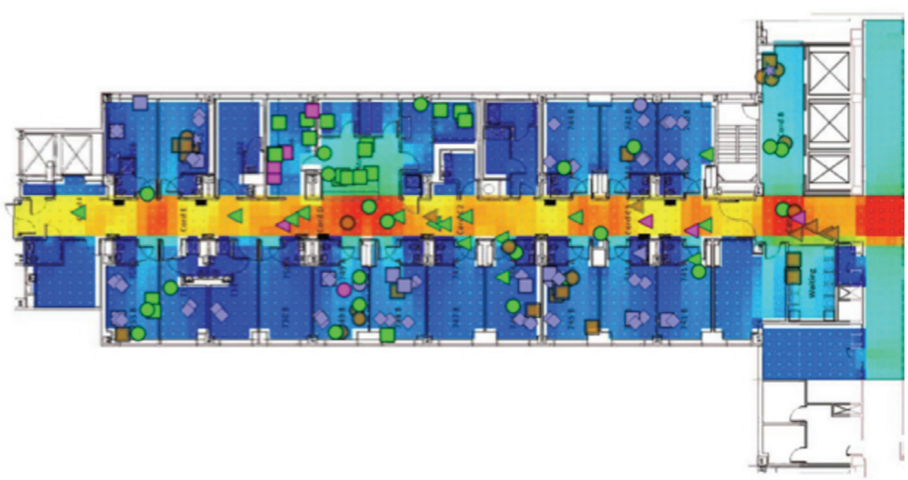


Figure 5: Behavior observation recordings overlaid on a space syntax map.



CONCLUSIONS

Simulations and mock-ups are gaining in popularity as design research tools (Peavey and Watkins, 2012). As these methods are integrated within the design process, they place increasing importance on integrating behavioral observations into a project work plan. Proper planning and data gathering are imperative for accurate model development (Peavey et. al., 2011). Using accurate data provides valid and oftentimes compelling feedback to streamline design decision-making. Providing for robust data collection, including behavioral observations, is vital to providing a realistic basis for physical and computer based models (Peavey et. al., 2011). Without the devotion of adequate time and resources at the start of a project, models created during later stages run the risk of having their findings distorted.

Simulations and mock-ups provide the opportunity to greatly impact design decision and provide valuable feedback; yet to be fully leveraged, these tools must show that they reflect reality. Behavior observation provides this link and allows design researchers to show the validity and reliability of their models.

Tool Template for Field Observation at Hospitals

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Paper developed in collaboration with Cannon Design Research Team

CONTEXT

Many research methods used in investigating healthcare environments focus on the perceptions or reports from patients and the staff. As self-reported data may be different from actual behavior, field observation as a predominantly qualitative method should be applied. In supplement to traditional quantitative approaches, it helps to better illuminate, understand, and explain the varied factors which may have a bearing on healthcare outcomes (Clarke, 2009).

Understanding the meaning of context is critical in healthcare environments research since the environments are designed for a system that keeps changing. From this standpoint, participant observation is preferred over non-participant observation, although the distinction between the two blurs (Atkinson & Hammersley, 1998; Cohen & Crabtree, 2006). Professionals who participate in the design of healthcare environments can be the participant observers, including architects, interior designers, healthcare professionals, and facility mangers. Undoubtedly, these professionals can collect the otherwise unexplored data of the built environment, such as the actual use vs. design intent. A professional distance should be maintained during the observation to ensure adequate observation and recording of data (Fetterman, 1998). While participant observation may combine more involved approaches, this paper suggests the observation with minimal interaction with the observed in order to reduce disruption to the healthcare activities being carried out on observation sites (Tonkin, 1984).

With different focuses, the observations can be conducted from pre-design programming to post-occupancy evaluation. To meet the unique needs of each project, observation tools may be individually developed, but a tool template allowing variable options is thought to be helpful for research development.

VARIABLES OF INTEREST

An observation tool template was drafted during the tool development for a cancer infusion center observation in 2010. It was later refined for two tools applied in different healthcare environments research. Along with the information of observation date, time, and location, this template focuses on people, their environment, and behavior. With different emphases, particular observation tools may target one group of people (e.g., patients), a certain type of behavior (e.g., wayfinding), or a specific area (e.g., waiting room).

- Human subjects included in the template are anonymous and recorded quantitatively in numbers by role and gender. Other demographic information such as age may be collected based on identification and data availability.
- Environments for observation are generally those open to the public, such as waiting rooms, hallways, or corridors. With special permission from the participants and the Institutional Review Board, hospital observations may be conducted in non-public areas such as patient rooms and treatment areas. To facilitate field observations, enlarged maps or floor plans of the selected areas may be utilized. If observation sites are large in size, zones should be defined to ensure visibility for observers and feasible schedules of data collection.

- The list of behaviors is expected to vary and should be specified in the context of individual projects. In this template, behaviors are grouped into two categories: individual behavior and social interactions. When focusing on patient populations, their uses of healthcare services should be recorded in the environmental context. Regarding staff members, the list should cover their general tasks during the caregiving activities of interest. To accommodate possible activities that are not included in the list of observations, a section for field notes is included in the template (Figure 1).

In order to foster meaning-making through self-reflection, field notes are strongly suggested in the template. Field notes reveal emergent themes and can be viewed as a preliminary analysis of observations. They should be written during the observation or as soon afterwards as possible. The development of field notes allows observers to fine-tune their attentions in ways that foster a more sophisticated investigation (Cohen & Crabtree, 2006). The notes can be rearranged or reorganized after observation, by topic or particular category, for specific research purposes.

Figure 1: Field Observation Template

		People					Environments				Bahavior						
		M= Male F= Female Y=Yes N= No					List of Environmental Features				Individual Behavior			Social Interactions			
		Role A		Role B													
	Timeslot	Number	Gender	Number	Gender	Other	Feature A	Feature B	Feature C	Other	Behavior A	Behavior B	Behavior C	Interaction A	Interaction B	Interaction C	Other
Location 1																	
Location 2																	
Location 3																	

Notes

1) e.g.: Patients waiting to use the toilet

2)

3)

4)

Map or Floor plan of the observation area

TOOL DEVELOPMENT AND USE

Two observation tools were developed using this template and applied in research of cancer infusion care and ICU environments. Tool design options are discussed in this paper in the context of these examples. Hands-on experiences of the field observations are also shared.

1. Infusion Center Observation at Simon Cancer Center

Process for Tool Development

This observation focused on patient, companion, and staff use of infusion treatment stations and related environments. During infusion treatment in the Center, most patients stayed in their infusion chairs, which were in a semi-open infusion bay with movable screens. The observation focuses were how the patients used their environments and what they did during the two- to eight-hour treatments. In this particular research context, the template was refined into the observation tool shown in Figure 2.

Figure 2: Infusion Center Observation Tool

	Occupant						Treatment Station Conditions					Patient Activities									Social Interaction		
	M= Male F= Female Y=Yes N= No						O= Open H=Half Open C=Closed E= Exterior I= Interior Y= Yes N= No					Y=Yes N= No									Y=Yes N= No		
	Patient Chair Occupied		Guest Chair Occupied		Staff Member Present	Total Number of Occupants in Pod	Door/Screen Position	Curtain Position	Window Shades	Orientation of Patient Recliner	Portable Screen In-Use	Looking out the window	Watching TV/DVD	Listening to Music	Reading	Viewing artwork	Using Computer	Talking on phone	Eating	Napping	Interacting with Guest	Interacting with other patients	Interacting with Staff Members
	Number	Gender	Number	Gender																			
Location																							
Lounge																							
Chair 1																							
Chair 2																							
Chair 3																							
Chair 4																							
Chair 5																							
Activities Observed							Number of Patients					Number of Guests									Time		
	1) Patients waiting to use the toilet																						
	2)																						
	3)																						

The People section of the template specifies the occupants of each treatment station, including patients, their companions, and the staff. The Environments section of the template was refined to the Treatment Station Conditions, such as the position of movable screens. In lieu of the Behavior section, two subsections were developed: individual Patient Activities and their Social Interactions with others. Two architects were trained before the field observation. Both have strong healthcare design backgrounds. The training included defining observation processes, creating a common coding system, and reaching an agreement on how to count activities and people. The observation coding was used consistently in the observation to ensure that similar decisions about similar events on different occasions. To facilitate observations from the designers' perspectives, the team decided to use the floor plan on a separate page to make field notes. Selected timeslots for observation were the early morning, late morning, early afternoon, and mid-afternoon.

Collected Data and its Reliability

During the two-day observation, a total of 165 patients were seen in the semi-open infusion bay. With support from the Infusion Center, patients and staff were not informed of the observation in advance to ensure the least interruption to daily activities in the Center. Data collected about people focused on occupants in the treatment stations. Data of the use of environments were binary and recorded by specific design items of interest. Regarding individual and social activities, the frequency of behavior was recorded during the observation hours. Importantly, the notes written down on the floor plan were found to be helpful for the recall of details, data input, and analysis. The inter-observer agreement was almost perfect (Kappa>0.8).

2. ICU Corridor Observation at OSF Milestone Project

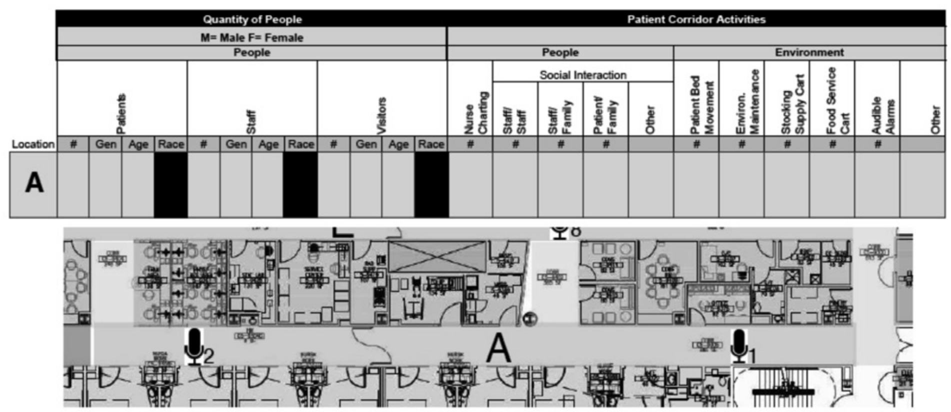
Process for Tool Development

This observation focused on corridor use in a 32-bed adult cardiac ICU and a 20-bed surgical ICU, with an emphasis on the role of a dedicated service corridor in noise control. The basic template was refined to reflect the subjects, their behaviors in the corridors, and environmental features of interest. Corresponding to the size of the ICUs, multiple observation zones were designated to ensure visibility. Similar to the training for the infusion center observation tool, two observers, including one interior designer and one with a public health background, were trained to ensure inter-rater reliability. Observations were conducted in each zone during six time periods per each of four observation days. Enlarged parts of the floor plan were inserted in the observation tool with tablets for observers' convenience in the field (Figure 3).

Collected Data and its Reliability

In the floor-plan notes, each observed subject was assigned a number for mapping environmental usage in the observation zone. The behavioral variables were individuals' walking, nurse charting, and various types of social interaction. The focus of the environmental portion was service traffic and noise. Specific data gathered included patient bed movement and service cart movement, as well as audible alarms. Based on Inter-rater reliability tests, the observation data is considered highly reliable (Kappa >0.7).

Figure 3: Observation Tool and Map for Adult Cardiac ICU



FINDINGS AND CONCLUSIONS

1. **Findings from the Infusion Center Observation**

   The designed semi-open stations seemed more private than expected. Interestingly, corner treatment stations were selected first by patients, followed by the stations in the center. A total of 27 out of 165 patients used their movable screens. Along with details of environmental use captured during observation, the findings were analyzed and discussed through a design charrette to assess design impact.

2. **Findings from the ICU Corridor Observation**

   The amount and type of corridor traffic including service carts, patient beds, staff, patient, and visitor communications were recorded and analyzed using the proportions of percentage. Observations revealed how the ICU layout impacted service, nursing and physician traffic and activities. The team concluded that the service corridor was not utilized to its full potential and suggested solutions. The findings were intensively reviewed by the interdisciplinary research team and included in a paper submitted for peer-reviewed journal publication.

These field observations done by designers have collected a depth of information about environmental utilization, which is valuable to evaluate the effectiveness of design strategies and to inform design decisions. These help to better understand the use of a design in its naturally occurring situation and contribute to refinement for future designs. For the purpose of design research, data from participant observations by designers may not be replaceable by other types of data. The data collected through designers' eyes supplies a context to interpret findings from analysis of patients' and staff's perceptions.

While using the template, tool development should focus on the process and data of interest to assess value for individual projects. It is important to understand what is observable and how much observers can capture while maintaining observation reliability. In addition, the team needs to agree on the priorities during observation to prevent missing information of interest. Regarding future use of the observation template, a dry run with draft tools is suggested to ensure the quality of observation. The dry run can be viewed as a group training to increase observer agreement and allow the team to assess the appropriateness of the variables included in the tool. Moreover, during the process of data analysis, the particular observation context and observers' embodiment should receive special attentions to minimize bias.

Due to its manual format, the template and tools based on it may be limited in the size and amount of paper that observers could carry during observation. They also present difficulties in capturing continuous information across time. Digital recording of data is suggested for future observations. Use of videos may be considered in the context of a project, with approval from the Institutional Review Board.

References

Atkinson, P., & Hammersley, M. (1998). Ethnography and Participant Observation. In N. Denzin & Y. Lincoln (Eds.), *Strategies of Qualitative Inquiry*. London: Sage.

Clarke, D. J. (2009). Using qualitative observational methods in rehabilitation research: Part one. *International Journal of Therapy and Rehabilitation*, 16(7), 362-369.

Cohen, D., & Crabtree, B. (2006). *Qualitative Research Guidelines Project* (Publication. Retrieved 06/01/2012, from RWJF: www.qualres.org/HomeEval-3664.html

Tonkin, E. (1984). Participant observation. In R. F. Ellen (Ed.), *Ethnographic research: A guide to general conduct* (pp. 213-223). London: Academic Press.

Reducing System Waste: Measuring Staff Walking in Acute Healthcare Settings

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CONTEXT

While a nurse walking in acute care settings has attracted attention for several decades from a human factors perspective, lately, the problem is also being viewed from a system efficiency and productivity viewpoint. However, there remains a fundamental problem in accurately and reliably measuring walking distance—without which examining the issue is difficult.

Previous studies have witnessed the use of different tools, but either with low reliability or with astronomical cost. Such tools include pedometers and custom-installed radio-frequency/ infrared tracking systems. Statistical techniques to predict actual walking distance from data generated from random origin-destination input by a sample of nurses is another direction being examined (Rapid Modeling Corporation, 2010). A reliable, accurate, and affordable option for measuring walking distances, however, has eluded healthcare design researchers.

In a recent study with the objective to validate a nurse walking predictor measure, the author used a combination of nurse locator system data and CAD drawings to develop a systematic and rule-based protocol for measuring walking in hospital units. This paper explains the protocol, equipment, and key steps in measuring walking distance using commercially manufactured nurse locator systems, when available/installed at study sites.

VARIABLES OF INTEREST

The key variable measured is the actual distance walked by nurses during a work shift. The study involved five units within the Texas Health Resources (THR) system hospitals. The data collection was comprised of collecting computer-generated reports on the sequential path taken by nurses from the time of arrival at the beginning of a shift until the end of that shift. It should be noted that these data are essentially reports of destinations on the unit visited by a nurse and time spent at each destination, sequentially, during a shift. It does not report the total distance walked.

The walking (sequential destination) data was obtained from HillRom's COMLinx system installed on each of the units included in the study. COMLinx is a real time personnel/ equipment locator system that uses RFID technology for tracking. Data from the system can be retrieved for any required time frame from the system's database. It provides sequential data on the exact location of nurses on a unit in a specified time period. Compared to other tracking methods, the COMLinx system offers an unobtrusive method for estimating walking, and is least disruptive to the people working on a unit.

TOOL DEVELOPMENT AND USE

Since COMLinx does not provide actual walking distance data, a two-step calculation protocol was developed to obtain walking distance figures. The sequential origin-destination location data generated by COMLinx were translated to measurable entities on the 'as built and operated' floor plans of the units under study. Several rules of translation were standardized to ensure instrument/protocol reliability.

For the purpose of standardization, all origin and destination points were located at the center of a room. All travel paths were traced at the center of corridors or hallways. Electronic (AutoCAD) drawings of the unit floor plans were used. Origin-destination points as well as turn points were marked by inserting a 'point' at the geometric center of rooms.

Actual distances walked were calculated by using the COMLinx system output for a particular nurse for a specific shift. Using p-lines, the travel paths of the nurses were traced sequentially from the first recorded origin to the last recorded destination during a shift. The total length of the p-line/s associated with a specific nurse record during a shift was adopted as the total distance walked by that nurse on that shift. The beginning time and the end time was recorded to provide the total length of time the nurse worked during that shift (note that the total length of time was different for each nurse, even though they were all on 12-hour shifts).

Standardization also included several assumptions regarding the nurses' behavior. It was assumed that:

- Nurses always took a shorter path if available through common spaces. For instance, if a choice exists between an origin-destination pair to include a longer hallway as opposed to a shorter path by travelling through a common space (such as a classroom, lounge, conference room, etc.), the shorter path was adopted unless the COMLinx system output clearly suggested that the longer path was traversed. This standard was adopted since many such instances were observed in the data.
- If a nurse was picked up by the sensor at a nursing station, it was always assumed that she went to a specific (standard) point in the nurse station.
- The nurses always arrived by the staff/service elevator (the initial access point on the unit) and always left the unit by the staff/service elevator.
- If staff lockers are located on the unit, the first stop for the nurses was always the locker room (note that locator sensors are not installed inside staff locker rooms and bathrooms).

FINDINGS AND CONCLUSIONS

As a part of the validation protocol, the study compared predicted walking distance (using the prediction measure) to actual walking distance data calculated from the COMLinx-CAD protocol. Two key analyses of the data were performed: (1) examination of data distribution of actual walking distances, and (2) comparison of the predicted walking distance with actual walking distance for the units under study.

Data on the actual distance nurses walked on each unit was analyzed to examine the attributes of data distribution. Analyses showed that the distribution of walking distances on each of the five units was close to the theoretical normal distribution. It is notable that the skewness and kurtosis were either close to zero or not large in comparison to their standard error (not close to two times the standard errors).

As regards to the prediction capacity of the measure validated in the study, of the five units, in four of the units the predicted mean walking distances were close to the actual mean walking distances as calculated from the COMLinx data. The differences between the predicted and actual mean walking distances were statistically small (within one standard deviation).

Nurse/Equipment locator systems, when available at study sites, offer a robust tool for measuring walking distances. This study systematically sought study sites where such systems are available. Other studies may adopt a similar strategy to obtain good quality walking data.

ACKNOWLEDGMENTS

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References:

Agency for Healthcare Research and Quality (2003). *The Effect of Workplace Conditions on Patient Safety.* Evidence Report / Technology Assessment, Number 74. Rockville: Author.

Graban, M. (2008). *Lean Hospitals: Improving Quality, Patient Safety, and Employee Satisfaction.* London, UK: Productivity Press.

Hendrich, A. (2006). *Hospital Work Environment: Implications for Nursing Practice and Patient Care Quality.* Invited Position paper at Healthcare Environments Research Summit, Georgia Institute of Technology, Atlanta, February 8-9.

Pati, D., Harvet, T., Ruchsdashel, R., Harvey, M., Caronia, S., & Milner, K. (2010). *Towards Optimizing Inpatient Unit Design and Operation: a Measure to Predict Nurse Walking Distance on Hospital Bed Units.* Dallas, TX: Center for Advanced Design Research & Evaluation (unpublished project report).

Rapid Modeling Corporation. (2010). From personal communication with author.

Location-Aware Technologies for Studying Resident Paths and Spatial Usage Patterns

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CONTEXT

Falls are among the most expensive events occurring in assisted living facilities and nursing homes. Falls across all settings cost the nation in excess of $19 billion annually (Stevens, Corso, Finkelstein & Miller, 2006) and are associated with numerous adverse outcomes, including hip fractures, disability, and death. To date, the science of fall prediction has evolved around the identification of risk factors such as unsteady gait, presence of psychoactive medications, and chronic health disorders such as Parkinson's disease and the dementias including Alzheimer's disease. It has been observed that chronic health disorders involving cognitive impairment are often linked to changes in locomotion (Hausdorff, 2007) and that locomotion changes related to spatial confusion precede later cognitive impairment. Kearns and colleagues have found that cognitive impairment in older adults is related to increased movement variability as measured by the Mini Mental Status Exam (Crum, Anthony, Bassett & Folstein, 1993). A more fine-grained analysis of the MMSE data revealed that increased movement variability was directly tied to low geographic orientation measure scores, suggesting that Kearns' elders were becoming lost in familiar areas (Kearns, Nams & Fozard, 2010; Kearns, Nams, Fozard & Craighead, 2011). A subsequent study (Kearns et al., in press) found that increased movement variability detected by this tool was an important predictor of future falls in ALF residents.

VARIABLES OF INTEREST

The core Ubisense RTLS technology present in Wander Track allows the mapping of interior spaces to an accuracy of better than 20cm in x, y, and z (altitude) relative to a user-determined origin, permitting the creation of a map of the geography of the space utilized by the occupants. Travel velocity and absolute location is derived from a small lightweight UWB transponder worn by the occupant of the space. Wander Track processes the RTLS data in real time to measure movement variability related to cognitive impairment in order to provide an online assessment of resident cognitive abilities and fall probability.

TOOL DEVELOPMENT AND USE

The Wander Track system represents an innovative use of Ubisense RTLS technology, which grew out of a DARPA-funded program of research whose early products tracked the position of many large shipping containers in the holds of cargo vessels. Subsequent miniaturization of the tracking transponder by Ubisense Inc. permitted its use as a human tracking technology. To date, Ubisense RTLS customers in industrial settings optimize man/machine operations by precisely programming handheld tools contingent on factory floor locations and time of day. The U.S. military uses the RTLS technology to train soldiers to efficiently conduct house-to-house searches, thereby minimizing unnecessary risk (see www.ubisense.net/en/rtls-solutions/). In an early validation study, Kearns and colleagues (Kearns, Algase, Moore & Ahmed, 2008) demonstrated that the RTLS technology could be used in small spaces for the resolution of the position of individuals to within 20cm in x, y, and z and that rotating the RTLS sending transponder at high speed did not significantly affect accuracy. However, placing the transponder within one meter of a wall did result in the introduction of significant location inaccuracies due to signal reflection.

FINDINGS AND CONCLUSIONS

Kearns and colleagues (Kearns et al., 2010) have found that cognitive impairment as measured by the Mini Mental Status Exam (Crum, Anthony, Bassett & Folstein, 1993) in older adults is related to increased movement variability measured using a fractal analysis program (Craighead, 2011), which is a central function of the Wander Track system. A more fine-grained analysis of the MMSE data revealed that increased movement variability was directly tied to low geographic orientation measure scores, suggesting that Kearns' elders were becoming lost in familiar areas (Kearns, Nams & Fozard, 2010; Kearns, Nams, Fozard & Craighead, 2011). A subsequent study (Kearns et al., submitted for publication) found that increased movement variability was an important predictor of future falls in assisted living facility residents.

FUTURE USES OF THE TECHNOLOGY

While fall prediction remains a core interest of these investigators, the high precision RTLS technology allows the evaluation of broad or specific environmental changes on human behavior by precisely tracking the location of the wearer at rates of several Hertz (Hz) as they move about their environment. The Ubisense tracking software allows the creation of geographic "hot zones" which tabulate a person's entries and exits, allowing the assessment of environmental manipulations on behavior (i.e., did increasing light levels make an area more attractive to residents? Did restructuring the nursing station improve patient flow and work efficiency?) The gathering of large amounts of data simultaneously on large numbers of persons can provide a sensitive tool for teasing out the effects of small and large interventions.

References

Craighead, J.D. (2011). Using Fractal Dimension to Assess Robot Operator Skill in a Search Task. *Journal of Intelligent & Robotic Systems, 64*(1), 97-118.

Crum, R.M., Anthony, J.C., Bassett, S.S., & Folstein, M.F. (1993). Population-based norms for the Mini-Mental State Examination by age and educational level. *JAMA, 269*(18), 2386-2391.

Hausdorff, J.M. (2007). Gait dynamics, fractals and falls: Finding meaning in the stride-to-stride fluctuations of human walking. *Human Movement Science, 26*(4), 555-589.

Kearns, W., Nams, V., Fozard, J., & Craighead, J. (2011). Wireless telesurveillance system for detecting dementia. *Gerontechnology, 10*(2), 90-102.

Kearns, W.D., Algase, D., Moore, D.H., & Ahmed, S. (2008). Ultra wideband radio: A novel method for measuring wandering in persons with dementia. *Gerontechnoly., 7*(1), 48-57.

Kearns, W., Nams, V., & Fozard, J. (2010). Wireless fractal estimation of tortuosity in movement paths related to cognitive impairment in assisted living facility residents. *Methods of Information in Medicine, 49* (6), 592-598.

Kearns, W., Fozard, J., Becker, M., Jasiewicz, J. & Craighead, J., Holtsclaw, L. & Dion, C. (Submitted for publication) Path tortuosity in everyday movements of elderly persons increases fall prediction beyond knowledge of fall history, medication use, and standardized gait and balance assessments. *Journal of the American Medical Directors Association.*

Stevens, J., Corso, P., Finkelstein, E., & Miller, T. (2006). The costs of fatal and non-fatal falls among older adults. *Injury Prevention, 12*(5), 290-295.

Developing a Physical Environmental Evaluation Component of the "Dementia Care Mapping" (DCM) Tool

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INTRODUCTION

The physical environment is considered as an important contributor to psychosocial, behavioral, and health outcomes of people with dementia in institutional environments (e.g., Calkins, 2001; Lawton, 2001; Sloane et al., 2002). Since the 1990s, several environmental assessment tools have been developed for use in dementia care settings. Two instruments have been well validated and used extensively in both stand-alone and integrated dementia care facilities. These two instruments are the *Therapeutic Environmental Screening Survey* (TESS-NH) (Sloane & Mathew, 1990; Sloane et al., 2002) and the *Professional Environmental Assessment Protocol* (PEAP) (Weisman et al., 1996). The Therapeutic Environmental Screening Survey examines 84 discrete items and one global item that cover multiple environmental domains including exit control, maintenance, safety, orientation/cueing, privacy, lighting, cleanliness, odors, physical appearance, noises, plants, outdoor areas, resident appearance, and access to public toilet from the main area. TESS-NH data provides a descriptive quantitative profile of the care environment, which is useful in comparing multiple facilities or in a pre-post renovation of a particular facility.

The Professional Environmental Assessment Protocol examines eight global dimensions of the built environment of a dementia care setting, including *awareness and orientation, safety and security, privacy, environmental stimulation, and social interaction* (all the eight dimensions identified earlier in this paper). These environmental dimensions are assessed on a five-point rating scale and conceptually based on the therapeutic goals of a dementia care environment (Cohen & Weisman, 1991), as identified earlier. PEAP was designed to supplement TESS-NH in terms of providing a holistic evaluation of the built environment in terms its potential for behavioral outcomes, whereas TESS-NH was designed to evaluate qualities of discrete environmental features. Another instrument, the Nursing Unit Rating Scale (NURS) (Grant, 1996), is based on six environmental dimensions—separation, stimulation, stability, complexity, control/tolerance, and continuity for people with dementia. Although this tool is useful to assess policy and program features on dementia care units, it falls short in evaluating the built environmental features in an effective way as the dimensions overlap between physical environmental and organizational aspects of the care setting. Other notable environmental evaluation tools include the *Environmental Indices* (Cutler et al., 2006), the *Stirling Environmental Audit Tool* (SEAT) (Fleming, 2009), and the Environmental Audit Tool (EAT) (Fleming, 2009).

There are two general limitations of these evaluation instruments. First, these walk-through environmental observation tools focus solely on the physical environment and do not explicitly account for any observed residents' behaviors or resident-staff interactions in the care environment. Observed characteristics of the built environment are ranked or evaluated based on their predicted potential to support or hinder behaviors in people with dementia. The foundation or premise of this linkage between objective quality of the environment and its ability to support individual and group behaviors is primarily based on previous literature and expert opinions. The missing data in these evaluations are any observed residents' behaviors. The residents' behavioral component (as identified in the therapeutic goals earlier), which is technically the ultimate outcome in association with environmental factors, remains implicit and assumed in the use of these evaluation tools. Second, the existing tools do not explicitly address the quality of the physical environment from the perspective of the person with dementia. With the increasing focus on person-centered dementia care in recent times, this is an important gap in the current approaches of environmental evaluation of dementia care settings. The psycho-social and behavioral manifestations of the condition of dementia vary across individuals, and are influenced by several factors, including the type of disease, stage in the disease progression, physical frailty, and personality. In sum, the existing tools are based on generalizations in understanding the built environmental aspects and behavioral associations, which overlook personal characteristics and the resultant variability of interrelationships between the individual persons with dementia and the physical environment of their setting. In order to address these issues, we have developed an environmental evaluation component designed to function along with a well-known dementia care evaluation tool—Dementia Care Mapping (DCM).

DEMENTIA CARE MAPPING

Dementia Care Mapping is a well-established tool originated by Tom Kitwood of the Bradford Dementia Group in Bradford, UK, for use by staff to examine and record components of quality of care and quality of life for residents with dementia in residential care facilities (Brooker & Surr, 2005; Innes & Surr, 2001; Kitwood & Bredin, 1992). DCM has gained international popularity and acceptance in the last ten years as a standardized measure for assessing quality of care and quality of life, as well as for practice development (Brooker, 2005; Brooker et al., 1998; Sloane, et al., 2007). The tool has been used in various settings and contexts that include: comparing quality of care and quality of life across facilities (Chung, 2004; Kuhn et al., 2004; Potkins et al, 2003), evaluating the impact of an intervention for people with dementia (Bredin, Kitwood & Wattis, 1995), group reminiscence (Brooker & Duce, 2000), and intergenerational programs (Jarrott & Bruno, 2003). DCM is conceptually grounded in the person-centered care approach proposed by Tom Kitwood (Brooker, 2004; Kitwood, 1997) that advocates maintenance of personhood in people with dementia in the face of cognitive decline. A person-centered care approach moves beyond the traditional biological model of care and incorporates psychological and sociological perspectives on dementia (Brooker, 2007). DCM is a tool that measures the extent to which the person-centered care approach is a reality for people with dementia (Innes, 2003; Innes & Surr, 2001).

The conventional or suggested use of DCM involves six continuous hours of observation or mapping of five to eight persons with dementia. In every five-minute time period, Behavioral Category Codes (BCC) and associated Well/Ill being (WIB) values are recorded. Although work on the DCM began in the early 1990s, in 2007 an updated and revised version was released, which made significant changes and developments in the protocol. Support for the validity and reliability of DCM is mixed; this can be attributed to the limited number of appropriately designed studies and the need for additional research to effectively identify any limitations in the current version of the tool, which in turn, would suggest areas for improvement (Cooke & Chaudhury, 2012). A current drawback of the tool is that it does not explicitly evaluate or incorporate possible influences of physical environmental features of the care setting on observed BCCs. The newly developed environmental evaluation component has been developed to address this limitation of the DCM tool.

THE PHYSICAL ENVIRONMENT EVALUATION COMPONENT FOR DCM

The physical environment evaluation component is comprised of two key coding schemes, Environmental Category Codes (ECCs) and Therapeutic Goals (TGs). The 20 ECCs (see Table 1) represent key environmental aspects and features of a dementia care setting. These are based on architectural features (e.g., orientation cues, walking paths), interior design features (e.g., furniture–type/arrangement, personally meaningful objects) and sensory attributes (e.g., auditory stimulation, glare). The environmental category codes have been identified by the authors as the recurring environmental features that affect behaviors of people with dementia in the existing literature on physical environment in dementia care settings (e.g., Brawley, 2006; Briller et al., 2001; Day et al. 2000; Zeisel et al., 2003). In particular, environmental features and concepts from two validated and widely used environmental evaluation tools, Therapeutic Environmental Screening Survey (Sloane & Mathew, 1990; Sloane et al., 2002) and the Professional Environmental Assessment Protocol (Weisman et al., 1996), were used to develop the new tool's Environmental Category Codes and Therapeutic Goals.

In order to be consistent with the format/structure of the Dementia Care Mapping tool, the Environmental Category Codes were constructed in a similar manner to those of the Behavioural Category Codes (BCCs) of DCM, such that there is a code for almost every letter of the alphabet. The letter 'E' is placed in front of each code to indicate that the code is part of the environmental evaluation tool.

Table 1: Environmental Category Codes

Environmental Category Code	Memory Cue	General Description of Category Code
EA	Auditory stimulation	Presence of auditory stimulation
EC	Cues (wayfinding)	Presence of environmental cues for navigation around unit
ED	Décor	Presence & degree of home-like décor
EE	Exits	Visibility of unit exits
EF-T	Furniture – type	Institutional vs. home-like furniture
EF-A	Furniture – arrangement	Arrangement of furniture that would support or impede participation in group activity or social interaction
EG	Glare	Presence of glare
EH	Handrails	Presence of handrails along main hallways
EK	Corridor length	Length of primary hallway on unit
EL	Lighting	Type of lighting in terms adequacy, brightness and institutional/residential appearance
EM	Meaningful objects	Presence of personally or culturally meaningful objects in the context of the resident's culture and preference
EO	Outdoor space	Presence of/access to outdoor space adjacent to unit
ER-S	Room – size	Size of common living/dining spaces
ER-C	Room – configuration	Configuration of common areas
ES	Smell	Odor on unit
ET	Tactile stimulation	Presence of everyday objects/activity props
EU	Unfamiliar hallway clutter	Hallway clutter
EV	Visual stimulation	Presence of visual stimulation
EW	Walking path	Presence of walking path
EZ	Zero effect	No perceived environmental effect, i.e., absence of any possible previously identified items

Full description and explanation of the ECCs are beyond the scope of this paper and are part of the training materials to be available to DCM environment tool users.

In the same way a BCC is linked with a Mood and Engagement Value (ME Value) in the Dementia Care Mapping tool, each ECC is linked with a positive or negative ECC Value (+1 or -1), depending on whether it appears to positively or negatively influence a resident's behavior, mood, and/or engagement. For example, the category EF-A (furniture arrangement) refers to the arrangement of furniture that facilitates conversation and social interaction among residents (e.g., placing chairs at right angles to one another, creating conversational groupings with seating, and coffee or end tables). Furniture that is arranged in a conversational pattern would be ascribed a +1 value, whereas furniture that is arranged around the periphery of the room and is therefore not supportive of easy visual and verbal contact would be assigned a –1 value (see Figure 1). As mapping data are collected at different times of a day, it is possible that the same space may have either a +1 or -1 value depending on any reorganization or movement in the furniture arrangement.

Figure 1: Example of ECC and Related ECC Values—EF-A (Furniture Arrangement)

ECC Value +1

ECC Value –1

The ECCs are identified in association with the observed BCCs. Trained observers (or mappers) position themselves as unobtrusively as possible within the care setting (but with clear sight lines to the residents being observed) and use a mapping table to record the appropriate BCC, along with up to two ECCs and their associated value (i.e., +1/–1). The policy allowing a mapper to record up to two ECCs associated with one BCC acknowledges the potential influence of more than one environmental feature on an observed behavior (e.g., furniture arrangement of the activity (positively or negatively) and noise from other residents/staff interaction in the activity room (negatively) may both affect a resident's observed behavior. While the BCCs are mapped every five minutes as per the rules of Dementia Care Mapping, related ECCs are mapped every 10 minutes in order to reduce burden on the observer. The 10-minute mapping interval also reflects the fact that ECCs are less likely to change as frequently as the BCCs. Data collected from the ECC observations can be used to generate both *Individual* and *Group Environmental Category Profiles* and *Environmental Category Value Profiles*. These profiles can, in turn, be used to identify physical environmental features of the care setting that foster or hinder person-centered care practice and lead to recommendations for positive environmental modifications.

The second coding scheme is based on eight outcome-oriented *Therapeutic Goals* (e.g., maximize awareness and orientation, support functional abilities) identified in the existing design for dementia as highlighting the potential role of the physical environment on socio-behavioural outcomes in people with dementia (e.g., Calkins, 1988; Cohen & Weisman, 1991; Lawton, 1986; Moos & Lemke, 1994; Regnier & Pynoos, 1992). In this environmental evaluation tool, each therapeutic goal is associated with a cluster of conceptually related Environmental Category Codes, an *Environmental Enhancer (EE* and an *Environmental Detraction (ED)*. For example, the therapeutic goal of "Maximize Awareness and Orientation" refers to environmental characteristics that enable residents to orient themselves to space, time, and activity. The related ECCs include: Cues (EC), Corridor Length (EK), Room Configuration (ER-C), Tactile Stimulation (ET), and Unfamiliar Hallway Clutter (EU). The *Environmental Enhancer (EE)* for this therapeutic goal includes physical features that assist residents in orienting themselves to space, time, and activity, e.g., small unit size, cluster-style floor plan, physical landmarks, familiar objects, contrasting colors, unique activity spaces, and furnishings unique to specific areas (lounge vs. dining). In contrast, the *Environmental Detraction (ED)* for this therapeutic goal includes physical features that limit residents' ability to orient themselves to space, time, and activity, e.g., large unit size, long double-loaded hallways (hallways with rooms on both sides), large multipurpose common areas, and unfamiliar institutional equipment (lifts, laundry carts, commodes). By recording relevant *Environmental Enhancers (EE)* and *Environmental Detractions (ED)* in conjunction with the ECCs during a mapping session, it is possible to identify (a) the environmental characteristics that appear to facilitate or undermine the individual residents' behaviours and (b) the therapeutic potential of the environment in the broader context of its therapeutic goals.

IMPLICATIONS

The newly developed environmental evaluation component embedded within the well-recognized Dementia Care Mapping tool provides an opportunity to systematically gather environmental data linked with observed resident behaviors. Environment-behavior researchers have used behavioral mapping as a research method to document observed behaviors in activity spaces in order to gain an understanding of person-environment interaction patterns. However, those efforts have not been linked to a validated behavioral coding tool for use in a dementia care context. We believe that the newly developed environmental evaluation component of DCM is a useful addition in the field of dementia care evaluation by addressing this missing aspect in current care evaluation tools and methods.

The new addition to current DCM will offer an important opportunity for staff in dementia care settings and design professionals involved in the planning and design of dementia care environments. Currently, DCM is used by staff in several countries as an evaluation and practice development tool by systematically observing and recording residents' behaviors and the quality of staff-resident interactions. With use of the environmental coding schemes presented in this chapter, staff members will be able to account for any potential physical environmental influences on the residents' behaviors. The new environmental data will provide an opportunity to identify areas of environmental modifications and/or renovations. Some of these interventions could be fairly modest, e.g., rearrangement of a furniture grouping to help residents better engage in activities/conversations, introduction of color contrast in appropriate areas for increased visual cues of environmental features, etc. Environmental interventions of larger scale can be identified as well based on the observed impact of environment (or lack thereof), e.g., need for easily accessible toilet from the activity space, direct access to a safe and secure outdoor space, etc.

Also, taking the environmental training program (to be offered as an online mini-course for the environmental evaluation tool users) and using the new tool would increase the environmental sensibility of the staff and empower them with an understanding of the importance of physical environmental features in positively or negatively contributing to residents' behaviors and mood. The second group of practitioners who can benefit from this tool is the design professionals, e.g., architects and interior designers. In a post-occupancy-evaluation of a facility—in this case, a dementia care setting—design professionals typically conduct observations and interviews. Observations utilizing standardized environmental evaluation tools (discussed earlier) would be based on previous research and expert opinions on the relationship between environmental features and behaviours of people with dementia. However, this new tool would provide them with *evidence-based data* based on real-time "environment-behavior" interaction, leading to individual or group targeted intervention strategies that are likely to be more meaningful and effective compared with the traditional method of design decisions. Moreover, the standardized coding schemes of the DCM environment tool provide an opportunity to compare care environments in multiple facilities in a valid and reliable manner.

References

Brawley, E. (2006). Design innovations for aging and Alzheimer's: Creating caring environments. Hoboken, NJ: John Wiley and Sons.

Bredin, K., Kitwood, T., & Wattis, J. (1995). Decline in quality of life for patients with severe dementia following a ward merger. *International Journal of Geriatric Psychiatry, 10,* 967–973.

Briller, S., Proffitt, M., Perez, K., Calkins, M., & Marsden, J. (2001). Maximizing cognitive and functional abilities . Vol. 2: Creating successful dementia care settings. Sydney: Health Professions Press.

Brooker, D. (2004). What is person-centred care for people with dementia? *Reviews in Clinical Gerontology, 13,* 215–222.

Brooker, D. (2005). Dementia Care Mapping: A review of the research literature. *The Gerontologist, 45*(Special Issue), 11-18.

Brooker, D. (2007). *Person-centred Dementia Care: Making Services Better.* London, UK: Jessica Kingsley Publishers.

Brooker, D., & Duce, L. (2000). Well-being and activity in dementia: A comparison of group reminiscence therapy, structured goal-directed group activity, and unstructured time. *Aging & Mental Health, 4,* 354–358.

Brooker, D., & Surr, C. (2005). *Dementia Care Mapping: Principles and Practice.* Bradford, UK: Bradford Dementia Group.

Brooker, D., Foster, N., Banner, A., Payne, M., & Jackson, L. (1998). The efficacy of Dementia Care Mapping as an audit tool: Report of a 3-year British NHS evaluation. *Aging and Mental Health, 2:1,* 60-70.

Calkins, M.P. (2001). The physical and social environment of the person with Alzheimer's disease. *Aging and Mental Health, 5, Supplement 1*, 126-130.

Calkins, M. P. (1988). *Design for Dementia: Planning Environments for the Elderly and the Confused.* Owings Mills, MD: National Health Publishing.

Cohen, U., & Weisman, G. (1991). *Holding on to Home: Designing Environments for People with Dementia.* Baltimore, MD: Johns Hopkins University Press.

Cooke, H., & Chaudhury, H. (in press). An examination of the psychometric properties and efficacy of Dementia Care Mapping. *Dementia: The International Journal of Social Research and Practice.*

Chung, J. C. C. (2004). Activity participation and well-being in people with dementia in long-term care settings. *OTJR: Occupation, Participation and Health, 24:1,* 22–31.

Cutler, L.J., Kane, R.A., Degenholtz, H.B., Miller, M.J., & Grant, L. (2006). Assessing and comparing physical environments for nursing home residents: Using new tools for greater research specificity. The *Gerontologist, 46:1,*, 42-51.

Day, K., Carreon, D., & Stump, C. (2000). The therapeutic design of environments for people with dementia: A review of the empirical research. *The Gerontologist., 40: 4*, 397–416.

Fleming, R. (2009). T*he Use of Environmental Assessment Tools for the Evaluation of Australian Residential Facilities for People with Dementia.* Hammond Care. Sydney: Australia.

Grant, L. (1996). Assessing environments in Alzheimer special care units. *Research on Aging, 18: 3,* 275-291.

Innes, A. (ed.) (2003). *Dementia Care Mapping: Applications across Cultures.* Baltimore: Health Services Press.

Innes, A., & Surr, C. (2001). Measuring the well-being of people with dementia living in formal care settings: the use of Dementia Care Mapping. *Aging and Mental Health, 5:3*, 258-268.

Jarrott, S. E., & Bruno, K. (2003). Intergenerational activities involving persons with dementia: An observational assessment. *American Journal of Alzheimer's Disease and Other Dementias, 18,* 31–37.

Kitwood, T. (1997). Dementia reconsidered: The person comes first. Buckingham, U.K.: Open University Press.

Kitwood, T., & K. Bredin, (1992). Towards a theory of dementia care: Personhood and well-being. *Ageing and Society. 12,* 269-287.

Kuhn, D., Kasayka, R.E., & Lechner, C. (2002). Behavioral observations and quality of life among persons with dementia in 10 assisted living facilities. *American Journal of Alzheimer's Disease and Other Dementias, 17:5,* 291-298.

Lawton, M.P. (1986). *Environment and Aging.* Second printing (orig. 1980). Albany, NY: Center for the Study of Aging.

Lawton, M.P. (2001). The physical environment of the person with Alzheimer's disease. *Aging and Mental Health, 5 (Suppl. 1),* S56-S64.

Lawton, M. P., & Nahemow, L. (1973). An ecological theory of adaptive behavior and aging. In C. Eiserdorfer and M.P.Lawton (Eds.), *The Psychology of Adult Development and Aging,* (pp. 657-667). Washington, DC: American Psychological Association.

Moos, R.H., & Lemke, S. (1994). *Group Residences for Older Adults.* New York, NY: Oxford University Press.

O'Connor, D., Phinney, A., Smith, A., Small, J., Purves, B., Perry, J., Drance, E., Donnelly, M., Chaudhury, H., & Beattie, L. (2007). Personhood in dementia care: Developing a research agenda for broadening the vision. *Dementia: The International Journal of Social Research and Practice, 6:1,* 121-142.

Potkins, D., Myint, P., Bannister, C., Tadros, G., Chithramohan, R., Swann, A., et al. (2003). Language impairment in dementia: Impact on symptoms and care needs in residential homes. *International Journal of Geriatric Psychiatry, 18*: 1002–1006.

Regnier, V., & Pynoos, J. (1992). Environmental interventions for cognitively impaired older persons. In J. Birren, B. Sloane, & G. Cohen (eds.). *Handbook of Mental Health and Aging.* (pp. 763-792). New York, NY: Academic Press.

Schwarz, B., Chaudhury, H., & Tofle, R. B. (2004). Effect of design interventions on a dementia care setting. *American Journal of Alzheimer's Disease and Other Dementias, 19:3,* 34-43.

Sloane, P. & Mathew, L. (1990). The therapeutic environment screening scale: An observational screening instrument to assess the quality of nursing home environments for residents with dementia. *American Journal of Alzheimer's Disease and Dementia, 5, 22-26.*

Sloane, P., Brooker, D., Cohen, L., Douglass, C., Edelman, P., Fulton, B.R., et al. (2007). Dementia care mapping as a research tool. *International Journal of Geriatric Psychiatry, 22,* 580-589.

Sloane, P.D., Mitchell, C.M., Weisman, G., Zimmerman, S., Foley, K.M.L., Lynn, M., et al., (2002). The therapeutic environment screening survey for nursing homes (TESS-NH): An observational instrument for assessing the physical environment for institutional settings for persons with dementia. *Journal of Gerontology: Social Sciences, 57B:2,* S69-S78.

Smith, M., Gerdner, L. A., Hall, G. R., & Buckwalter, K. C. (2004). History, development, and future of the Progressively Lowered Stress Threshold: A conceptual model for dementia care. *Journal of the American Geriatrics Society, 52:10,* 1755 – 1760.

Weisman, G., Lawton, M.P., Sloane, P.S., Calkins, M., & Norris-Baker, L. (1996). *The Professional Environmental Assessment Protocol.* Milwaukee, WI: School of Architecture, University of Wisconsin at Milwaukee.

Zeisel, J., Silverstein, N.M., Hyde, J., Levkoff, S., Lawton, M.P., & Homes, W. (2003). Environmental correlates to behavioral health outcomes in Alzheimer's special care units. *The Gerontologist, 43:5,* 697-711.

Developing Intensive Care Unit (ICU) Nurse and Physician Questionnaires to Assess the Design of ICUs as Work Environments

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CONTEXT

The purpose of the study was to develop questionnaire instruments with reliable and valid measures for describing and assessing the Design of ICUs as Work Environments. Although a significant amount of work has been done on the assessment of individual provider clinical skills, healthcare team functioning and organizational attributes, and managerial practices in ICUs (e.g., Brook and Lohr, 1985; Cleary and McNeil, 1988; Lohr, 1989; Roper et al., 1988; Shortell et al., 1991), gaps exist in our ability to assess reliably and validly the design of ICUs as work environments. That is because instruments to assess ICU design as work environments are almost non-existent in the literature. In a somewhat relevant study, Rashid (2007) provides the psychometric analysis of an instrument designed to evaluate staff perception of the effects of the physical environment on patient comfort, patient safety, patient privacy, family integration with patient care, and staff working conditions in adult intensive care units. It should, however, be noted that the scales provided by Rashid (2007) emphasize the effects of various design features on aspects of work processes. Therefore, an instrument that focuses on staff perception of environmental characteristics of ICUs in a more direct way without associating them to any process-related issues is still needed for assessing ICUs as work environments.

DESIGN

The initial instruments to assess the Design of ICUs as Work Environments was created based on the structure and content of a federal office environment assessment questionnaire. The psychometric analysis of the items and scales of the federal office questionnaire was provided in studies reported earlier (Rashid et al., 2005, 2006, 2009). Both the content and structure of the existing questionnaire were modified significantly to describe the design characteristics of ICU work environments better. Items on staff walking and use of time were not included in the federal office instrument, but were added to the new measure for ICUs. Separate questionnaires for physicians and nurses were developed to allow for greater clarity of the referents for many questions. Altogether, 88 five-point Likert-type items (strongly disagree to strongly agree) were modified or developed for the nurses' questionnaire and 86 items for the physicians' questionnaire. Items included individual and unit level design features and satisfaction, and were organized based on concepts found in the literature—space, furniture, and equipment; environmental features; privacy and interruption; features supporting individual work; features supporting teamwork; locations of equipment, materials, and supplies; and staff walking time.

Several strategies were used to increase the reliability of the instruments. First, each specific attribute of workplace design was described using multiple items. Second, the questions were alternated between positively and negatively worded items to avoid response set bias by encouraging careful attention to each item of the questionnaires. Finally, where possible, items with previous evidence of relevance and reliability were used.

The preliminary questionnaires' items were reviewed by a group of experts that included one researcher working in the healthcare design research field, two design consultants who also worked as critical care RNs, one critical care physician, and one critical care RN. Based on the reviewers' comments on clarity, distinctiveness, and appropriate reading level, some new items were added, and some old items were modified and/or rephrased in the final version of the questionnaires.

The final questionnaires were administered to a convenience sample of four ICUs serving different patient groups in two large urban hospitals. The IRB-required information and cover sheets were attached to the questionnaire to ensure that participants fully understood the intent of the study and the consequences of their participation. A total of 55 nurses and 29 physicians completed the survey.

Cronbach's Alpha was used to measure internal consistency, and factor analysis was used to provide construct-related validity. Convergent and discriminant validity were assessed through examining bivariate correlations between relevant scales/items. Analysis of variance was used to identify if the between-group member responses were significant among the four units.

FINDINGS

Cronbach's Alpha values for all preliminary scales but three indicated acceptable reliability. These scales with Cronbach's Alpha above the cutoff limit include a six-item 'space, furniture, and equipment of primary work space' scale with Cronbach's Alpha of 0.86; a seven-item 'environmental quality and controls of primary workspace' scale with Cronbach's Alpha of 0.81; a seven-item 'privacy and interruption' scale' with Cronbach's Alpha of 0.87; a seven-item 'unit features supporting teamwork' with Cronbach's Alpha of 0.85; and a three-item 'use of time in relation to walking scale with Cronbach's Alpha of 0.79.

Factor analysis indicated that some preliminary scales could be partitioned into subscales for finer descriptions of the design of ICU work environments. For example, the seven-item 'environmental quality and controls of primary workspace' scale was partitioned into two subscales: environmental quality of primary workspace and environmental control of primary workspace. The seven-item 'privacy and interruption' scale was partitioned into two subscales: privacy in primary workspaces and privacy in other spaces. The seven-item 'unit features supporting teamwork' scale was partitioned into two subscales: primary spaces for teamwork and other spaces for teamwork.

Correlational analysis provided strong evidence of convergent and discriminant validity of all the scales and subscales. The significance level of F-statistics showed that the units were significantly different from each other, providing evidence of more between-unit variance than within-unit variance.

CONCLUSIONS

The Design of ICUs Work Environments is a key concern, for it contributes significantly to staff fatigue, stress, and reduced performance. The measures developed in the study offer a promising departure point for more rigorous analysis and evaluation of ICU design at a time when the importance of such studies is growing.

References

Brook, R. H., Lohr, K. N. (1985). Efficacy, effectiveness and quality: Boundary-crossing research. *Med Care,* 25,710.

Cleary, P. D., McNeil, B. J. (1988). Patient satisfaction as an indicator of quality of care. *Inquiry*, 25, 25.

Lohr, K. N. (Ed.). (1989). Advances in health status: Conference proceedings, *Med Care;* 27(suppl), S2.

Rashid, M. (2007). Developing scales to evaluate staff perception of the effects of the physical environment on patient comfort, patient safety, patient privacy, family integration with patient care, and staff working conditions in adult intensive care units: a pilot study. *Crit Care Nurs Q, Jul-Sep, 30(3),* 271-83

Rashid, M., Kampschroer, K., Wineman, J., Zimring, C. (2006). Spatial layout and face-to-face interaction in offices – A study of the mechanisms of spatial effects on face-to-face interaction. *Environment and Planning B: Planning and Design, 33,* 825-844.

Rashid, M., Wineman, J., Zimring, C. (2009). Space, Behavior, and Environmental Perception in Open Plan Offices: A Prospective Study. *Environment and Planning B: Planning and Design, 36,* 432-449.

Rashid, M., Zimring, C., Wineman, J., et al. (2005). The Effects of Spatial behaviors and Layout Attributes on Individuals' Perception of Psychosocial Constructs in Offices. In: Proceedings of the Fifth International Space Syntax Conference (pp. 71-87). Delft, Netherlands.

Roper. W. L., Winkenwerder, W., Hackbarth, G. M., et al. (1988). Effectiveness in healthcare: An initiative to evaluate and improve medical practice. *New England Journal of Medicine,* 319, 1197.

Shortell, S. M., Rousseau, D. M., Gillies, R. R., Devers, K. J., Simons, T. L. (1991). Organizational assessment in intensive care units (ICUs): Construct development, reliability, and validity of the ICU nurse-physician questionnaire. *Medical Care,* 29(8), 709-726.

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