

Research on Nursing Unit Layouts: An Integrative Review

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Author: Mahbub Rashid

Department: Architecture

University/Institution: University of Kansas

Town/City: Lawrence

State: KS

Country: USA

mrashid@ku.edu

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STRUCTURED ABSTRACT

Purpose: To present an integrative review of the research studies on nursing unit layouts.

Methodology: Studies selected for review were published between 1956 and 2014. For the purpose of this review, a framework for integrative review was developed using research orientations. The three primary dimensions—technical, psychological, and social—of the designed environment and various combinations of these dimensions were used to define the research orientations of these studies.

Findings: Of all the publications reviewed for the paper, 21 presented technical orientations, 16 psychological orientations, 3 social orientations, 20 psychotechnical orientations, 10 sociotechnical orientations, 2 psychosocial orientations, and 13 presented psychosociotechnical orientations. With only a few exceptions, several issues related to nursing unit layouts were investigated no more than one time in any one category of research orientations. Several other seemingly important issues including patient and family behavior and perception, health outcomes, and social and psychosocial factors in relation to unit layouts have not been studied adequately.

Research implications: Future studies on nursing unit layouts will need to focus on patient and family behavior and perception, health outcomes, and social and psychosocial factors in different units. They will also need to focus on developing theories concerning the effects of layouts on the technical, psychological, and social dimensions of nursing units.

Originality/value: Despite a long history of research on nursing unit layouts, an integrative review of these studies is still missing in the literature. This review fills in the gap using a novel framework developed based on research orientations.

Keywords: integrative review, nursing unit layout, research methodologies, research orientations

Article Classification: Literature review

INTRODUCTION

A nursing unit can be defined as an area in a hospital or other healthcare delivery setting where patients with similar needs are grouped together to facilitate the delivery of care by healthcare professionals. The layout of a nursing unit is an important environmental design feature, because it contains spatial information of practical relevance. When properly labeled, it is possible to identify all the spaces and functions along with their shapes and sizes from unit layout. It is also possible to identify the relationships among different spaces and functions in a unit based on how they are configured in the layout. A study involving several unit layouts, therefore, may show how some units are similar to or different from the other units in terms of spaces and functions.

Studies of nursing unit layouts need not be limited to spatial and functional analysis only. They can be conducted to understand the society and the profession that produce and use them. That is because one is often able to read in a unit layout the clinical services of the unit and how these services are delivered. Therefore, a comparative study of nursing unit layouts may show how units providing similar clinical services are different from one another or how units providing different clinical services are similar to one another in terms of identity and integrity. Studies involving unit layouts of a particular period can reveal the more general models of medical and design practices of the period. In contrast, studies involving unit layouts of different periods can reveal how the models of medical and design practices have evolved over time.

Unit layouts can do a great deal to encourage communication and collaboration by eliminating visual and physical barriers. Conversely, they can all too easily disrupt existing relationships by imposing unnecessary barriers. The identity of a practice team may depend on how visible the members are to the patient and patient family within a unit. It may also depend on how the members are visible to each other within the unit.

Unit layouts can affect one's sense of privacy, safety and security depending on the degree to which she is visible to others in the unit. For example, an open layout may affect a patient's sense of privacy negatively, while improving her sense of safety and security for she can see others on the floor. In contrast, a layout with private-patient rooms may help improve a patient's sense of privacy, while reducing her sense of safety and security for she cannot see others on the floor.

For these and many other reasons, research studies on nursing unit layouts, when done rigorously, may serve many purposes. These purposes may include, but may not be limited to, the following: 1) to understand the historical evolution of unit layouts; 2) to help develop design guidelines and rigorous design theories to help design better nursing units; 3) to help resolve functional and/spatial issues that arise in the context of clinical practice; 4) to help test layout criteria against a set of clinical objectives; 5) to help develop theories explaining patterns and underlying structures of interactions among people, objects and environments in nursing units; and 6) to help test, refute, or falsify a theory linking environment, behavior, psychology and culture in nursing units. Given the importance, it is not surprising that rigorous studies on unit layouts were already being done in the 1940s and 1950s (e.g., Nuffield Report by the Nuffield Provincial Hospitals Trust & University of Bristol, 1956). Yet, a comprehensive review of the studies on nursing unit layouts has not yet been written. Therefore, the aim of this paper is to provide a framework for an integrative review, and then use the framework to review and organize the research studies on nursing unit layouts to fill-in the existing gap in the literature. Before all this, however, the methods used for searching, collecting and selecting research studies on nursing unit layouts for this review are described.

THE LITERATURE

For the review of research studies on nursing unit layouts, books, book chapters, peer-reviewed articles, technical reports or whitepapers, and dissertations were collected through numerous social sciences,

medicine and health, and arts and humanities databases made available by the library system of a research university. Some of the databases included in the search were ABI/INFORM, Academic OneFile, Arts and Humanities Citation Index, BioMed Central, Cochrane Library, Google Scholar, JSTOR, MEDLINE, ProQuest, PsycINFO, PsychiatryOnline, PubMed Central (PMC), ScienceDirect, and Social Sciences Citation Index. In addition, all the proceedings of the conferences of the Environmental Design Research Association (EDRA) and all the articles in the knowledge repository of the Center for Health Design (CHD) were also searched for this review.

Among the keywords used in the search were 'unit', 'ward', 'nursing unit', 'nursing station', 'nursing suite', 'inpatient unit', 'intensive care unit', 'critical care unit', 'hospital', 'healthcare', and 'healthcare facilities'. When appropriate these words were used in combination with 'layout', 'space', 'area', 'function', 'room', 'setting', and 'design'. Every publication that contained the word 'layout', 'space', 'area', 'setting', or 'design,' in the title and/or abstract was selected for further scrutiny. Some publications without the word 'layout', 'space', 'area', 'setting', or 'design' in the title and/or abstract were also selected for further scrutiny because they contained these words in their subtitles, headings or subheadings, or they frequently contained these words in the texts.

To further enhance literature search, references provided in the more recent literature were also examined carefully. Unfortunately, more research studies on nursing unit layout were published in the last 15 years than the last 50 years before that. Therefore, the expected snowballing effect based on the references in the more recent studies did not occur. Most studies refer to the same set of previous research studies that others before them had cited. The oldest of the studies included in this review was published in 1956 and the most recent was published in 2014. The literature of the 1950s was included in the review, because by this time the era of modern hospitals was well established, and the importance of hospital design was already being recognized in the research literature. Of these publications reviewed, 3 were published in the 1950s, 6 in the 1960s, 9 in the 1970s, 6 in the 1980s, 6 in the 1990s, 24 in the 2000s, and 32 were published between 2010 and 2014. They included 9 books and book chapters; 7 technical reports and

dissertations; and 69 peer-reviewed article with 6 reporting literature reviews. In total, 85 studies were selected for review.

Like any designed environment, it is possible to categorize the environment of nursing units into two broad categories—the ambient and the physical environment. The ambient environment may include such non-physical features as color, views, sound/noise, lighting, temperature, and air quality of the unit, while the physical environment may include such features as spatial layout and its properties including size, shape, configuration, physical proximity, accessibility and/or visibility; individual spaces or rooms including their size, shape, and configuration; furniture, fixtures, technology and equipment; and finish materials, artwork and environmental graphics. Therefore, the publications included in the review included (1) the studies that deal with the ambient and the physical environment of nursing units in relation to different unit layouts and their properties, (2) the studies on behavior, psychology, and health in nursing units in relation to different unit layouts and their properties, and (3) the studies of different nursing unit layouts and their properties in relation to history, society, and culture. Studies on any individual design feature/s, such as patient rooms, staff work areas, support services, technology, lighting or noise, were not included in the review if these studies did not involve unit layouts. Likewise, studies on individual behavioral, psychological, social and technological issues were not included in the review if these studies did not involve unit layouts.

The literature selected for the review covered numerous topics on nursing unit layouts, including the historical evolution of nursing unit layouts in relation to medical practice; the current design issues, such as flexibility and spatial constraints, of unit layouts; the relationships between unit layouts and medical/health outcomes; the occupancy and behavioral patterns in units; the psychology of occupants in units with different layouts; the theoretical and mathematical models for improving unit efficiency through layout design; and many more topics. In simple words, these studies were thinly spread over numerous topics and did not permit a *systematic review* combining the evidence of multiple sources on a specific topic. These studies also used several methods and methodologies, both qualitative and

quantitative. As a result, *meta-analysis* that combines the evidence from empirical research studies by employing statistical methods was not appropriate for the review. Therefore, *integrative review* that combines qualitative and quantitative research to provide a comprehensive understanding of the studies done so far on various issues related to a subject was selected as an approach for this review of studies on nursing unit layouts (Whittemore and Knafl, 2005). A framework for such an integrative review is discussed next.

THE CONCEPTUAL FRAMEWORK FOR INTEGRATIVE REVIEW

Most integrative reviews of research studies on healthcare environments are often organized based on medical and/or non-medical outcomes (e.g., Rashid & Zimring, 2008; Ulrich et al., 2004, 2008).

Notwithstanding their importance for evidence-based healthcare design, these reviews have limitations.

Due to a focus on outcomes, they often overlook variations in research design of the studies being reviewed. For example, studies on nosocomial infections in relation to handwashing in nursing units often use different settings, methods of data collection and methods of analysis. Regarding settings, some studies may focus on different locations of handwashing sinks; some others may focus on the same locations of handwashing sinks in different units; and still others may focus on the handwashing culture in the unit/s. Regarding methods, some may use field observation; some others may use interviews; and still others may use recorded archival data available from the unit. Yet, in outcome-based integrative reviews, all these studies would generally be put in one category.

For an integrative review, therefore, one could categorize the literature based on research designs. In fact an earlier version of this paper considered such an approach for an integrative review of the research studies on nursing unit layouts. That is because a literature review based on research design can explain how the quality of evidence produced by one study on a phenomenon is different from another study on the same phenomenon; why and how studies involving different topics related to a phenomenon require

different research designs; finally, it can also shade light on the theoretical motivations behind these studies. However, in this approach it is often difficult to categorize those studies that use similar research designs but report different outcomes, or those that report similar outcomes using different research designs. Even for the studies with similar research designs and/or outcomes, the qualities of study can vary significantly. For example, it can be hard to differentiate some studies that use quantitative techniques to analyze the data collected using qualitative techniques from those that use simple descriptive techniques to analyze the data collected using quantitative techniques.

At the other extreme, one could also categorize the literature based on research paradigms. Again, different authors have used different research paradigms that are not entirely similar. For example, Crotty (1998) suggests three research paradigms, which are objectivism, constructionism, and subjectivism. Mertens (1998) also suggests three but different research paradigms. Mertens paradigms include positivism/postpositivism, interpretivist/constructivist, and emancipatory. Others, like Morgan and Smircich (1980), use a continuum that extends from subjective to objective research approaches. While these research paradigms are helpful for understanding some of the fundamental philosophical assumptions made by a researcher, they appear to be too generic to provide any concrete guidance concerning the strengths and limitations of the strategies and tactics of a particular research.

To overcome the limitations of a literature review based on outcomes, research designs or research paradigms, the paper uses a conceptual framework defined based on research orientations (**Figure 1**). The framework defines the research of the designed environment along three interrelated dimensions, which are (1) *materials and technology* including all physical and non-physical design features, (2) *history, society and culture*, and (3) *behavior, psychology, and health*. For its purpose, the paper defines a study as having *technical* orientation if it deals directly with materials and technology of the designed environment; a study as having *social* orientation if it deals with the history, society and culture of which the designed environment is a part; and a study as having *psychological* orientation if it deals with behavior, psychology, and health in relation to the designed environment using individuals as units of

analysis. It is important to note here that when a study uses individual's perception of different physical and non-physical features of a designed environment instead of the 'objectively' measurable properties of these features, it is considered a study with psychological orientation rather than a study with technical orientation for the purposes of this review.

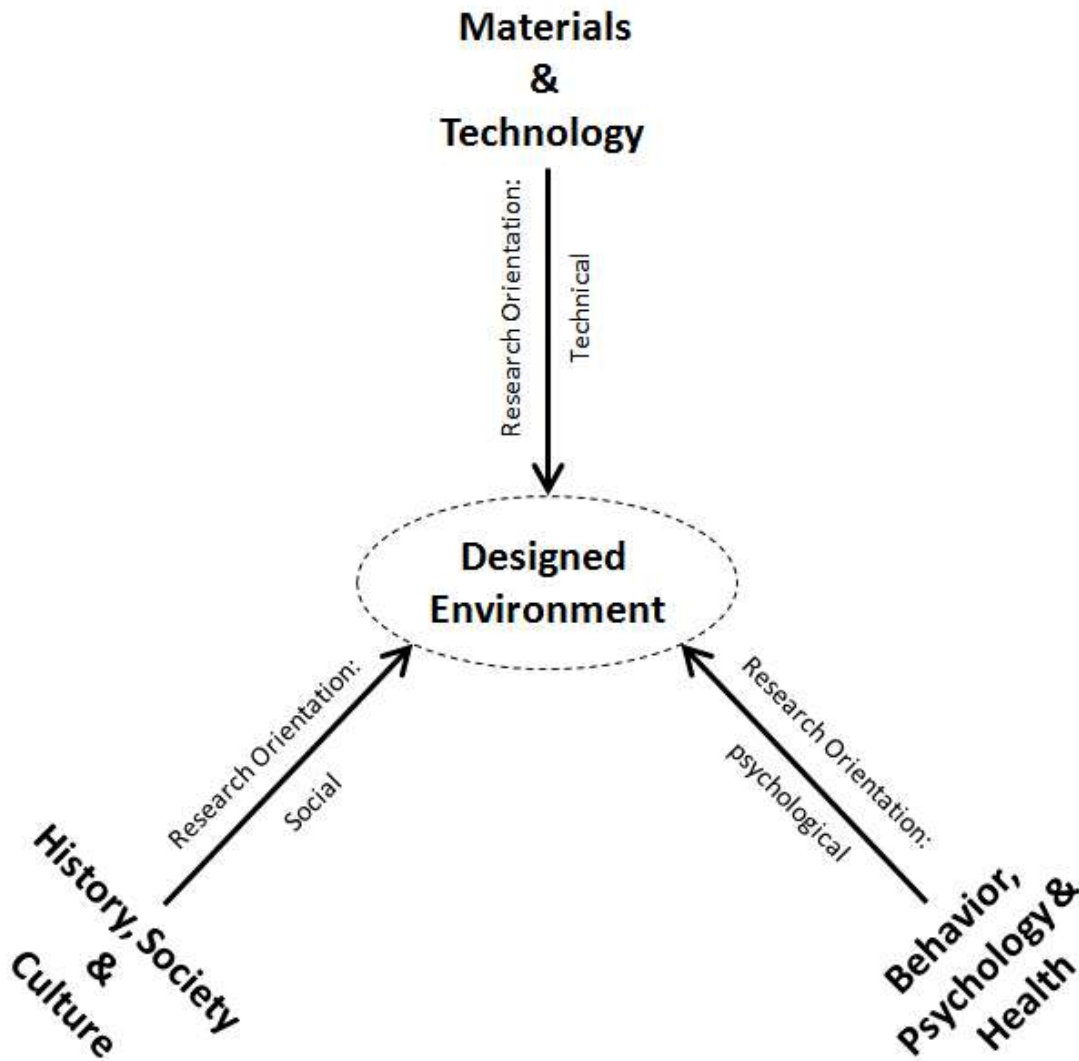


Figure 1: Three basic orientations of research involving the three domains of the designed environment.

Since the three dimensions of the designed environment often interact and overlap, the three basic orientations of research then can be used for defining further research orientations to help organize research studies on the designed environment (**Figure 2**). They are *sociotechnical* describing the

interaction between the social and the technical; *psychotechnical* describing the interaction between the psychological and the technical; *psychosocial* describing the interaction between the social and the psychological; and *psychosociotechnical* describing the interaction among the technical, social, and the psychological dimensions of the designed environment. Next, the paper uses the above framework of integrative review to organize and present the research studies on nursing unit layouts.

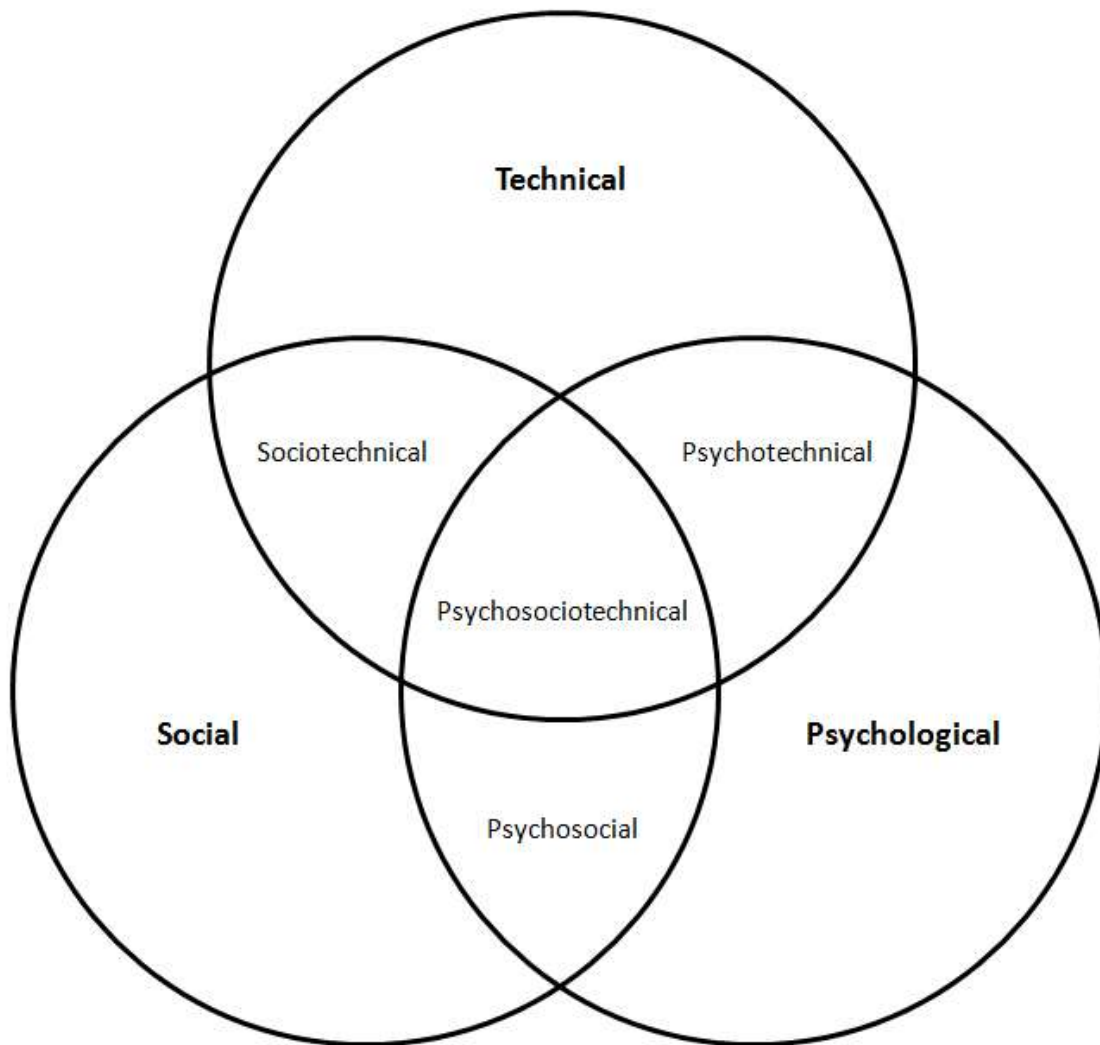


Figure 2: Various orientations of research involving the designed environment.

THE REVIEW

Of all the publications reviewed for the paper, 22 were considered having technical orientations, 16 psychological orientations, 3 social orientations, 20 psychotechnical orientations, 10 sociotechnical orientations, 2 psychosocial orientations, and 13 were considered having psychosociotechnical orientations. Some publications, such as Nuffield Report (1956) and Thompson and Goldin (1975), were included in more than one category for they contained research studies with different orientations.

In order to organize and review the literature, a master table was created containing the name of the author/s, the year of publication, the type of publication, the aim/s of study, the settings, sample population and/or the areas of research, the methodology and methods of study, the findings, and the research orientation of each publication. However, for space limitations the **table** in the appendix provides the data for the 51 papers out of the 55 papers that were published in peer-reviewed journals since 2000. The other 4 papers of this group reported literature reviews; hence, were not included in the table.

Research Studies with Technical Orientation

Research studies with technical orientation investigate and describe nursing unit layout features without making any explicit attempts to associate these features with psychological and social dimensions of the units. These studies can be put into three groups, which are summarized below.

Studies describing unit layout and design

Studies in this category primarily describe unit layouts covering both physical and non-physical (ambient) features (Allison and Hamilton, 2008; Cadenhead and Anderson, 2009; Catrambone *et al.*, 2009; Durnham, 2012; Nuffield Report, 1956; Rashid, 2006, 2014, 2014a; Van Enk & Steinberg, 2011). They cover different types nursing units, such as medical-surgical units, intensive care units (ICUs), and neonatal intensive care units (NICUs). They also cover different issues in different unit layout types

including the use of space and provision of facilities (Nuffield Report, 1956) ; patient visibility; distance to hygiene, toileting, charting, and supplies; unit configuration; percentage of private rooms; and presence or absence of carpeting (Catrambone *et al.*, 2009); space allocation for different functions, unit size, patient room size and design, support and service area layout, and family space design (Cadenhead and Anderson, 2009; Rashid, 2006, 2014a, 2014b); the relationship between net and gross square footages (Allison and Hamilton, 2008; Durnham, 2011); and the features of ambient environment - sound level, light level, temperature and humidity (Van Enk & Steinberg, 2011).

Most of these studies compare unit layout types against each other using well-defined design/technical variables. They use various techniques for data collection, including field measurements, behavioral observations, interviews, and content analyses of published materials. Some studies use one, while others use some combinations of these techniques for a more comprehensive technical dataset.

Some interesting findings concerning unit layouts reported in these studies are as follows: (1) Significant inter- and intra-hospital variation in unit configurations, percentage private rooms, carpeting, visibility, and distance to supplies and charting exist in ICUs and medical surgical units in the US (Catrambone *et al.*, 2009). (2) The ICUs awarded by the Society of Critical Care Medicine, the American Association of Critical Care Nurses, and the American Institute of Architects during the last two decades use several design features that are associated with positive outcomes in research studies (Cadenhead and Anderson, 2009; Rashid, 2006, 2014a, 2014b). (3) Unit net to gross ratios and the mean net to gross ratio for each unit category vary widely in US hospitals (Allison and Hamilton, 2008). (4) Units with private rooms allow for a patient care environment that can be maintained within a smaller range of variation nearer optimal environmental conditions (Van Enk & Steinberg, 2011).

Studies using mathematical models

Studies in this category use mathematical models or techniques to describe unit layout features (Lippert, 1972; Lu, 2010; Lu and Zimring, 2010). Lippert (1972) develops a mathematical technique that

determines nurses' travel on the unit taking into account unit geometry, the number of patients typically visited, and the order in which they are visited. Applying the technique to a set of theoretical unit layouts, Lippert finds that some nursing units are always better than others regarding nurses' travel and others may be better or worse depending on the number of patient visited and the order in which they are visited.

Lu (2010) and Lu & Zimring (2010) provide a mathematical technique, called the targeted visibility index (TVI), to describe the structure of visual fields, more specifically patient bed visibility, in nursing units. TVI is expressed as the ratio of the average of the targeted visibility values of all locations and the total number of targets in a unit, and is used for describing the degree to which an observer can see all the targets in the unit. The authors use TVI to compare visibility in the three units used by Trites *et al.* (1970) discussed below, and found support for the claim that the circulation spaces in the radial units had the highest visibility, followed by that in the double-corridor units, and then by that in the single-corridor units.

The mathematical techniques described in these papers are useful for comparing unit layouts of different shapes and sizes. However, one major limitation of these techniques is the fact that geometry is only factor among many affecting behavior, psychology, health and culture in nursing units. These other factors may include, but not limited to, individual difference of study participants, unpredictable patient requests for a nurse, routine activities, staffing, assignment of nurses to patients, teamwork, and the interaction between geometry and behavior. Therefore, when using these models in explanatory studies, researchers must control the factors that may pose as threats to validity.

Studies using simulations

Studies in this category use simulations to determine unit layout criteria. Many early simulation models, developed based on queuing theory or mini-max theory, were used to determine the volume of patient, the length of stay, the amount of wait time, the number of recovery beds, the number of patient beds or oxygen outlets required for any given population, etc., that could potentially affect unit size and layout.

Several of these early studies were reported in Thompson and Goldin (1975). Other early examples of these studies include Fetter and Thompson (1965), Pelletier and Thompson (1960), Thompson (1959), Thompson and Fetter (1969), and Thompson and Pelletier (1959). A survey of some of the recent computer simulation studies on hospitals and nursing units can be found in Brailsford *et al.* (2009), Jun *et al.* (1999), and Sobolev *et al.* (2011).

In one recent example of simulation study, Pati *et al.* (2012) used a computer-based simulation tool to investigate the impact of decentralization of nursing support spaces on nurses' walking distances and their unproductive use of time. In running the simulation, the authors standardized several factors, including the floor layout, unit size, staffing ratio, and frequency of different tasks (developed based on data collected from a national sample survey of 700 RNs). They ran the simulation on a standard, hypothetical, 30-bed unit over a 12-hour day shift. The only variables they manipulated in the series of simulation runs were the locations of 8 nursing support spaces. With each manipulation of support spaces, the change in walking distance was recorded for all nurses, compared with a baseline centralized condition. The findings of their simulation study suggest that total walking time in nursing units can be reduced by as much as 67.9%, depending on the level of decentralization. Care quality and efficiency issues can also be significantly addressed through appropriate levels of decentralization. It should, however, be noted here that Pati and his colleagues do not take into account the negative effects of decentralization on peer support, socialization, mentoring, and consultation with other providers in relation to efficiencies and efficacies.

Among the limitations of most of simulation studies, like the one reported by Pati *et al.* (2012), is the fact that they generally assume that cause-and-effect relationships in the real-world context are always unclear, and that variables and their interactions are hard to isolate at any given time due to probabilistic factors. Therefore, they are designed to enact particular cases reliably and accurately using a predefined set of variables and assumptions demonstrating how a setting may work now and in the future. However, these simulations may become unusable as the assumptions change based on new knowledge.

Research Studies with Psychological Orientation

Research studies with psychological orientation investigate behavior, psychology, and health in nursing units without making any explicit attempts to associate them with technical and social dimensions of the units. These studies can also be put in three groups, which are summarized below.

Studies using behavioral observations

Two studies were found in this category (Nuffield Report, 1956; Gadbois et al., 1992). In one behavioral study described in the Nuffield report (1956), every member of the nursing staff, on all shifts, was followed during one complete tour of duty. In all, 27,327 journeys were recorded and analyzed, and it was found that these journeys—each simple excursion from one point to another—made by a nurse in the course of her tour of duty, usually amounted to between 300 and 400, and accounted for between 2 and 2 ½ miles of walking. The study also found, quite surprisingly, that despite differences in the layout of the nursing units at each of the three hospitals, the proportion of all journeys made between beds, between beds and supply points, and cross-journeys were similar; and so was the proportion of all journeys made from the beds to the kitchen and dirty- and clean-utility rooms in these units.

In another behavioral study, Gadbois et al. (1992) reported the spatial and temporal organization of the work of nurses in U-shaped surgical and medical units of a private hospital in Paris, France. It focused on the number of trips undertaken by nurses in completing the various aspects of their work. The study showed that trips made during the execution of nursing work were conditioned by the spatial organization of the unit, but were also related in part to the dynamics of the nursing team's activities, and in particular to the occurrence of interruptions. The study was unable to identify the main design factors that ultimately resulted in excess travel, and indicated a need to distinguish between those components of the work load that are amenable to analysis of spatial characteristics only and those that relate to collective work within the nursing team and cooperation between different units.

Studies using semi-structured questionnaires

Five studies were found in this category (Harvey *et al.*, 2006; Pati *et al.*, 2008; Pati *et al.*, 2012; Zimring and Seo, 2012; Lindeke *et al.*, 1998). Harvey *et al.* (2006) and Pati *et al.* (2008) interviewed 48 stakeholders in nursing and nursing-support services at six hospitals to describe flexibility in nursing units. Pati *et al.* (2012) used verbal protocol data and shadowing frontline personnel along with in-depth semi-structured interviews in five acute care hospitals to identify and examine potential factors affecting the optimization of flexibility in nursing units. Zimring and Seo (2012) described actual tactics and strategies to implement successful acuity-adaptable units (AAUs) in several institutions. Lindeke *et al.* (1998) described nurse practitioners (NPs) opinions and perceptions of the barriers related to limitations of space or facilities using their comments on current space constraints.

Some important findings of these studies are as follows: (1) Flexibility in unit layout and design are be related to (a) peer line of sight; (b) patient visibility; (c) multiple division and zoning options; (d) proximity of support; (e) resilience to move, relocate, and interchange units; (f) ease of movement between units and departments; and (g) multiple administrative control and service expansion options (Harvey *et al.*, 2006; Pati *et al.*, 2008). (2) The optimization of flexibility in nursing units is affected by factors in the four domains of design process: systemic, cultural, human, and financial (Pati *et al.*, 2012). (3) Any successful implementation of AAUs requires choosing the right specialty to serve; adopting the acuity adaptable unit model for the entire facility; bringing in and training the right people; changing culture through communication; and using acuity-adaptable unit clusters (Zimring and Seo, 2012). (4) The effects of space constraints in nursing units on nurse practitioner practice can be explained using (a) inefficient use of time, (b) limitations on productivity, (e) confidentiality concerns, (d) patient teaching constraints, (e) documentation difficulties, (f) conferencing and consulting limitations, and (g) effects on professional image (Lindeke *et al.*, 1998).

Most psychological studies on nursing units that use semi-structured questionnaires help uncover issues that cannot always be described precisely, hence go unnoticed regarding nursing unit layouts. Despite their importance, most studies on nursing unit layouts reported here lack generalizability. Either the

sample size was too small, or triangulation was not done to ascertain the truth-value of the opinions of those interviewed. Concerning the three flexibility studies mentioned above (Harvey et al., 2006; Pati, et al., 2008, 2012), it should also be noted that inpatient unit flexibility may be dependent on the flexibility needs of the rest of the hospital. Therefore, future studies linking micro and macro flexibility needs, and exploring design issues arising out of such needs are needed.

Studies using structured questionnaires

A few psychological studies of nursing units use structured questionnaires (Hurst, 2008; Huseby, 1969; Mourshed and Zhao, 2012; Parker et al., 2012; Pendell & Kevin, 1976; Sears & Auld, 1976; Stevens et al., 2009, 2010; Watkins et al., 2011). Using structured questionnaires, these research studies include many more study sites and respondents than observational studies or studies using semi-structured questionnaires do. As a result, these studies are often more generalizable, and they are better able to overcome any threats to validity when designed appropriately. However, one major limitation of these studies is that they measure the physical environment using perceptual scales, and not geometric or physical scales. Another limitation is that these studies are unable to include any critical emerging issues beyond those that are already identified in survey questionnaires during the data collection phase.

Among the early examples, Huseby (1969) studied differences in patients' opinion in radial, single and double-corridors nursing unit layouts. Sears and Auld (1976) studied the effects of 'cubiclization' of beds on staff perception in 36 nursing units from 16 hospitals. Pendell and Kevin (1976) used questionnaire survey data collected from four hospitals to develop methods which would describe both organizational and unit design characteristics and differentiate hospitals in terms of these characteristics.

Among the recent examples, Hurst (2008) described how the best unit design features could help improve nursing efficiency and effectiveness using patient dependency, nursing activity, workload, nursing quality and staffing data collected from 375 UK units. Stevens et al. (2009) assessed staff workplace quality perceptions, and Stevens et al. (2010) assessed parents' satisfaction using data collected through

questionnaire surveys from a NICU that moved from an open-bay layout to a private-room layout. Stevens et al. (2010) also compared the old NICU facility with the new one using a subset of 16 items indicative of family-centered care. Mourshed and Zhao (2012) explored healthcare providers' perception of design factors in hospitals including nursing units. Parker *et al.* (2012) studied the effects of the nursing unit design on nurse perception of the supportive quality of the physical work environment, stress, job satisfaction, and the psychological impact of the work environment on their overall well-being. Finally, Watkins et al. (2011) studied differences in patient and nurse outcomes between the same-handed and mirrored unit configurations using questionnaire survey data collected from 8 medical-surgical inpatient units in 2 hospitals.

Some of the findings reported in these studies in relation to unit layouts are as follows: (1) Patients may favor the radial and double-corridor units more than single-corridor units (Huseby, 1969). (2) The younger a hospital is the better its design features for nursing staff (Pendell & Kevin, 1976). (3) Nurses with different titles, i.e. different characteristics in terms of education, experience, and job assignment, perceive hospital conditions differently (Pendell & Kevin, 1976). (4) Nurses on different shifts may perceive the environmental factors of climate and architecture as being different (Pendell & Kevin, 1976). (5) Though nursing efficiency and effectiveness are better in open plans (Nightingale units), it may be possible to replicate the Nightingale conditions by, for example, equalizing occupancy, throughput and staffing and maximizing nurses' substations to engender similar outcomes in other units (Hurst, 2008). (6) Female healthcare providers are more perceptive about visual, acoustic and olfactory factors, compared to their male counterparts (Mourshed and Zhao, 2012). (7) Spatial design factors may explain a significant part of the variance of healthcare providers' perception of nursing units and hospital environments even though these factors may not rank as important as environmental maintenance factors (Mourshed and Zhao, 2012). (8) Centralized nursing units may provide improved perception of patient access and professional communication among staff (Parker et al., 2012). (9) Parents whose babies receive care in the single-family room facility may be more satisfied with the NICU environment and care than parents

whose babies receive care in the open-bay facility (Stevens et al., 2010). (10) Staff may be more satisfied with workplace quality in single-family patient room NICU than in open-bay NICU (Stevens et al., 2009). (11) Compared with mirrored unit configurations, same-handed unit configurations may show lower noise levels, better sleep quality, more frequent approaches to patients' right side, and improved satisfaction with organization of the workspace at patients' bedsides (Watkins et al., 2011).

Research Studies with Social Orientation

Research studies with social orientation investigate socio-cultural and historical issues of nursing units without making any explicit attempts to associate them with psychological and technical dimensions of the units. The literature reports only 3 relevant studies with social orientation. In one of these studies, Beales et al. (1978) use ethnographic data collected over five years to investigate conflict, misunderstanding, poor design, and poor administration in small healthcare facilities of Great Britain. In the other, Liu *et al.* (2014) use ethnographic data from two general medical units of an acute care hospital in Australia to investigate how physical environments affect communication processes for managing medications and patient safety in acute care hospital settings. In the third study, Choi and Bosch (2013) use more limited observational data to compare family presence and interaction in a patient-centered unit with that in a traditional unit.

Some of the unit layout related findings reported in these studies are as follows: (1) Separate practices are better kept in separate units, each with its own waiting area, for improved organizational effectiveness. (2) Communication, or lack of it, is a common problem in small healthcare facilities in UK (Beales et al., 1978). (3) Environmental interruptions can affect communication processes about medications, and unit layout issues can be a factor affecting communication difficulties (Liu *et al.*, 2014). (4) The patient-centered unit may help increase family presence in the patient rooms and family interaction with patients, when compared with the traditionally designed unit (Choi and Bosch, 2013).

The three studies with social orientation are interesting for they provide first-hand descriptions of cultural and organizational issues related to nursing unit layout and design. However, it should be noted that the quality of these studies often depends on the researcher and her skills to observe, record, and interpret; the complexity of the context in which the study is being conducted; and the length of time the researcher is eager to spend in the field collecting data.

Research Studies with Psychotechnical Orientation

Studies with psychotechnical orientation investigate the relationships of behavior, psychology and/or health outcomes with unit layout features. These studies are summarized below in three different groups.

Studies involving behaviors and unit layout features

The studies in this category are discussed in two groups – studies in one of these groups investigate the effects of layouts on behaviors by comparing the differences in carefully selected unit layouts (Carlson et al., 2006; Freeman and Smalley, 1968; Hendrich *et al.*, 2008; Jaco, 1972; Nuffield Report, 1956; Shepley and Davies, 2003; Thomas & Goldin, 1975; Whitehead et al., 1984; Yi and Seo, 2012), while the studies in the other group uses space syntax techniques to investigate the effects of layouts on behaviors (Cai and Zimring, 2012; Choudhary et al., 2010; Hendrich *et al.*, 2009; Lu *et al.*, 2009; Rashid et al., 2012; Sagha Zadeh *et al.*, 2012).

Among the early comparative studies, Freeman and Smalley (1968) used personal travel time of medical and surgical patients to explain how the position of substations, monitoring devices and the number of patients affect the amount of travel. Jaco (1972) examined staff behavior in terms of direct care provided and trips made in circular and rectangular unit layout. Whitehead et al. (1984) described the redesign and evaluation of a 30-bed psychiatric unit. In the original unit, the corridors were long, uniform in shape, drab in color, and poorly lighted. The day room afforded little privacy and was oriented to watching

television. Dormitories lacked privacy. In the redesigned unit, long institutional corridors were broken up, flexibility of use was added to group and day room areas, functional uses and humanistic values were accentuated through color and graphics, and dormitories were subdivided for privacy.

Among the recent studies, Shepley and Davies (2003) compared two nursing units in facilities for persons with HIV/AIDS in terms of noise and nurse walking. Carlson et al. (2006) described the design process and experiences of neonatal nurses, as the unit moved from a traditional multi-bed NICU to a private room NICU. Yi and Seo (2012) followed nurses in an ICU during the medication administration task, and recorded movements and activities on unit floor plans.

Some important findings concerning unit layouts reported in these comparative studies are as follows: (1) Travel of patients may be affected by the position of substations, monitoring devices and the number of patients (Freeman and Smalley, 1968). (2) Unit layout and design features may affect staff behavior, depending on how units are utilized socially, psychologically, medically and administratively, but they may not sufficiently account for all outcomes (Jaco, 1972). (3) A unit with attractive furnishings and an accessible visiting room may improve the patients' subjective experience (Whitehead et al. 1984). (4) Changes in layouts may change staff and patient behaviors and their distribution (Whitehead et al. 1984). (5) The amount of walking in a unit may depend on its layout with nursing staff in the radial unit walking significantly less than staff in the rectangular unit. However, noise levels in these units may not vary (Shepley and Davies, 2003). (6) A NICU with private room may help improve staff, parent, and patient outcomes (Carlson et al., 2006). (7) Walking during medication administration may not depend on the size of a unit. Rather, it may depend on the level of experience of a nurse. A more experienced nurse may make more unnecessary stops and may walk more since she may interact with others more frequently (Yi and Seo, 2012).

In the other studies with psychotechnical orientation, researchers use space syntax techniques in investigations involving behavior and nursing unit layouts. [See Haq (2012) for a review of Space Syntax

related studies in healthcare settings.] In one of these studies, Hendrich *et al.* (2009) use a generic concept of centrality of Space Syntax, namely *integration*, to explain the observed behavioral patterns in medical-surgical units. In general, centrality defined using space syntax techniques describes how visible and accessible a space is in relation to all other spaces in the layout – higher centrality is associated with better visibility and accessibility. In their correlational studies using similar generic concepts of centrality, Cai and Zimring (2012) explain the frequency of nurses' interaction and the awareness of peers' work in a neurological unit, and Rashid *et al.* (2012) explain the effects of space on interaction-related behaviors in four ICUs of two major hospitals in a large metropolitan area. Also using similar concepts, Sagha Zadeh *et al.* (2012) describe spatial relationships among the clinical spaces in five contemporary medical-surgical units. In contrast, Lu *et al.* (2009) uses a centrality measure computed based on targeted visibility (also see above) to explain the distribution of staff density.

Some important findings reported in these space syntax studies are as follows: (1) The frequency of shorter visits to patient rooms and the total amount of time spent in these rooms may be positively associated with spatial centrality of these rooms (Hendrich *et al.*, 2009). (2) Interaction-related behaviors and co-awareness among nursing staff on unit floor may be associated with spatial centrality (Cai and Zimring, 2012). (3) The association between the centrality measures computed based on targeted visibility and the distribution of staff density may be stronger than that between the generic centrality measures and the distribution of staff density (Lu *et al.*, 2009). (4) Interaction-related behaviors among nurses, physicians and visitors in different spaces of ICUs may be associated with centrality of these spaces (Rashid *et al.*, 2012). (5) The frequency of caregivers' movement is high in spaces with high centrality values, such corridors and nurses' station. These are also the places with the greatest possibility of interruptions (Sagha Zadeh *et al.*, 2012).

These studies using space syntax techniques show how the objective patterns of visibility and accessibility of a unit are important for behaviors in the unit. Yet the number of studies in nursing units remains insufficient. These studies are also quite narrow in scope. Either they use only one or two case

studies; or they look at a very narrow set of behaviors. Therefore, more studies investigating the importance of visibility and accessibility for behaviors in nursing units are needed.

Studies involving psychology and unit layout features

Three studies in this category are Alalouch & Aspinall (2007), Shepley *et al.* (2008), and Trzpuc & Martin (2010). Alalouch & Aspinall (2007) investigated perceived privacy in nursing units in relation to spatial centrality measured using Space Syntax techniques in six different types of multi-bed units in UK. In the study, participants' chosen locations for privacy showed a systematic relationship with spatial properties of the unit layouts. Their choices for both high and low privacy locations were best represented by integration and control. At a unit level participants' preference for greater privacy was for units with low integration and high control values; and within any unit, at a bed location level participants' preference for privacy was in lower integration and lower control locations.

Shepley *et al.* (2008) explored the implications of neonatal intensive care unit (NICU) single-family rooms (SFRs) relative to open-bay arrangements on staff preferences and experiences. Three tools, the Perception of the Job Satisfaction Scale, the Nurse Stress Scale, and the Physical Environment Survey, were used to compare differences between two types of NICU configurations. According to the study, staff members in the SFR units had higher job satisfaction and lower stress than those in the open-bay unit. All of the subfactors associated with stress were potentially affected by the SFR versus open-bay options. Staff members were more satisfied with SFR units.

Finally, Trzpuc & Martin (2010) conducted semi-structured interviews of staff members to test several hypotheses developed based on the centrality of spaces measured using space syntax techniques in three medical-surgical units with different layouts. They found that nurses' perception of the potential functional benefits of visibility and accessibility in the units did not match the potential benefits of these units predicted based on their centrality values. While the finding of the study is interesting, several confounding factors existed in the study.

Studies involving behaviors, psychology and health, and unit layout features

Only three studies were identified in this category. In one, Leaf *et al.* (2010) study if patient outcomes are significantly impacted by ICU design. Six hundred sixty-four patients admitted to the medical ICU (MICU) of Columbia University Medical Center during 2008 were included in this retrospective study. Patient outcome measures, which included hospital mortality, ICU mortality, ICU length of stay (LOS), and ventilator-free days, were compared based on random room assignment. Rooms that were not visible from the MICU central nursing station were designated as low-visible rooms (LVRs), whereas the remaining rooms were designated as high-visible rooms (HVRs). Overall hospital mortality did not differ among patients assigned to LVRs vs HVRs; however, severely ill patients (those with Acute Physiology and Chronic Health Evaluation II scores >30) had significantly higher hospital mortality when admitted to an LVR than did similarly ill patients admitted to an HVR (82.1% and 64.0%, n = 39 and 75, respectively; P= .046). ICU mortality showed a similar pattern. ICU LOS and ventilator-free days did not differ significantly between groups. Therefore, it was concluded that severely ill patients may experience higher mortality rates when assigned to ICU rooms that are poorly visible by nursing staff and physicians.

In another, Lu *et al.* (2014) reanalyzed Leaf *et al.* (2010) data using targeted visibility index (TVI) to describe visibility of patient rooms (see above for more on TVI). They found that among the sickest patients (those with Acute Physiology and Chronic Health Evaluation II > 30), visibility of patient rooms as measured by TVI accounted for 33.5% of the variance in ICU mortality (p = 0.049), thus providing additional support for the importance of visibility of patients in relation to patient mortality.

In the third study, Stevens *et al.* (2012) present a comprehensive comparison of open-bay (OPBY) and single-family-room (SFR) neonatal intensive care unit (NICU) designs as services moved from OPBY NICU to SFR NICU. Data included sound and illumination levels, time needed to establish full enteric feedings, patient satisfaction, staff perception of the environment and care, nurse anxiety score, numbers of staff and nursing staff per shift, nurse walking, patient sleep time, and adjusted direct cost of care

before and after the move. The findings overwhelmingly support the single-family-room (SFR) neonatal intensive care unit (NICU) designs over the traditional open-bay (OPBY) units. The findings, however, should be interpreted and extrapolated with full awareness of significant organizational changes that occurred during and after the move to the unit.

Research Studies with Sociotechnical Orientation

Research studies with sociotechnical orientation investigate the relationships between social and technical dimensions of nursing units. Examples of this kind of study are found in a few books and articles published over the last few decades providing interpretive historical accounts of the development of hospitals including nursing units (Adams, 2008; Adams & Schlich, 2006; Connor, 1993; Currie, 2007; James and Tatton-Brown, 1986; Markus, 1993; Prior, 1988; Taylor, 1997; Thomas & Goldin, 1975). Some of these studies provide nuanced interpretations of the spatial organization in hospitals in relation to the discursive practices of which they form a part (Markus, 1993; Prior, 1988). Some others are interesting for they refute an oversimplified notion that medical and technological innovations were the only forces that shaped unit design and layout as we know them today (Adams, 2008; Adams & Schlich, 2006).

In contrast to the above interpretive studies, a sociotechnical study by Kim and Lee (2010) show how the techniques of space syntax can be applied to assess the Whole-life Target Value Design (TVD) of healthcare facilities. They used three hypothetical nursing units - shallow-plan, deep-plan and courtyard-plan - to determine which alternative is the most cost-efficient in terms of users, and found that the deep-plan has the lowest and the shallow-plan the highest user costs. However, the study discussed user costs in qualitative terms due to a lack of financial evidence on user costs.

A few studies have also investigated staffing, an important organizational issue, in relation to nursing unit layout and design. Based on a review of these studies, Seelye (1982) concluded that the two measures of unit layout and design essential to effective and efficient nursing care are: (1) place all facilities, stores

and services at the point where they are needed most so that nurses spend as little time as possible in walking or unnecessary communication; and (2) include features which facilitate maximum contact between a nurse or nursing team and the patient(s) for whom she or they are responsible. He also concluded that how these two principles are incorporated effectively in unit layout and design would depend on (a) the number, turnover and dependency (nursing needs) of the patients who are nursed in it; (b) the number, qualifications, experience, characteristics and length of stay on the unit of the nursing staff; (c) the level or standard of care considered acceptable; and (d) nursing policies, especially in relation to unit organization.

Research Studies with Psychosocial Orientation

These studies investigate how individuals interact with a social environment or how social patterns affect individuals in different settings. One of the two studies found in this category investigated psychosocial behaviors among nursing staff (Tyson et al., 2002) and that other investigated psychosocial behaviors among patients (Stahler et al., 1984). Tyson et al. (2002) conducted a comparative study involving psychological, social and psychosocial aspects in four psychiatric units. The old 31-bed long-stay unit was open, while the new 16-bed long-stay unit had four self-contained areas. The old acute unit was a 32-bed unit, while the new acute unit has 28 beds, eight of which are in a secure area. The study had three components: observations, questionnaires, and interviews. Each was administered approximately six months prior to the move to the new units and then approximately six months after the move. According to the study, the new acute unit had more patient interactions but the new long-stay unit had less patient interactions. There were no significant differences for interaction with staff. The percentage of positive interactions increased and neutral interactions decreased in the new units. Significant difference between the old and the new units was observed for emotional exhaustion and personal accomplishment, with an increase in burnout in the new environment.

In contrast, Stahler et al. (1984) conducted their study at a remodeled women's unit and a non-altered comparison unit comprised of similarly dysfunctional male geriatric patients. Observations of patient behavior and interviews of patient and staff were conducted before and after the move. According to the study, patient-staff interaction increased, as expected, immediately following the remodeling; but patients also displayed increased hostility and tension as well as decreased sociability and self-maintenance skills. Five weeks after the move, however, it was found that pathological behavior had decreased below the level found prior to remodeling. None of these changes was observed on the comparison ward. In addition, interviews indicated that environmental enhancement improved morale among both patients and staff.

Both the studies in this category highlight a dichotomy that may sometimes be found in the outcomes of specific design features. Features considered advantages for the patients may become sometimes disadvantages for the staff, or vice versa. Since changes in the physical and organizational environments are inextricably linked, the behavioral changes found by these studies are likely to reflect the impact of a combination of the two, which none of these studies investigated.

Research Studies with Psychosociotechnical Orientation

Research studies with psychosociotechnical orientation investigate the relationships among psychological, social, and technical dimensions of nursing units. In general, these studies are more comprehensive in nature, and use multiple methods to collect data. In some cases, they use Generalized Linear Models (GLMs) to investigate associations among the factors representing various dimensions. These studies are discussed in two groups: studies that are conducted in natural settings and those that are conducted in simulated settings.

Studies in natural settings

Studies in this group include Alalouch et al. (2009), Donahue (2009), Gurascio-Howard and Malloch (2007), Hua et al. (2012), Shepley (2002), Sturdavant (1960), Trites et al. (1970), Watkins et al. (2012),

and Zborowsky et al. (2010), as well as some that were provided in Nuffield Report (1956) and Thompson and Goldin (1975). In contrast, Richtey and Stichler (2008) discuss several psychosociotechnical issues to be considered in determining the optimal number of patient rooms for an acute care patient care unit.

In one early example, Sturdavant (1960) evaluated the effectiveness of circular units for use in intensive care against a rectangular unit, where service operated in each unit, successively, under conditions that were matched as closely as possible except for the visual contact and travel conditions. Using a study design similar to Sturdavant (1960), Trites et al. (1970) evaluated the impact of nursing unit design on the activities and subjective feeling of nursing staff working on radial, double and single corridor general units. In a recent example, Alalouch et al. (2009) investigated the effect of age, gender, previous experience of space and cultural background on people's chosen spatial location for privacy in six different types of multi-bed wards or units in six different hospitals in UK. In another recent example, Zborowsky et al. (2010) investigated how nursing station designs (i.e., centralized and decentralized nursing station layouts) affect nurses' use of space, patient visibility, noise levels, and perceptions of the work environment. In yet another recent example of a psychosociotechnical study, Watkins et al. (2012) explored the impact of unit design and healthcare information technology (HIT) on nursing workflow and patient-centered care (PCC).

For the studies reported in Sturdavant (1960) and Trites et al. (1970), information on nursing staff activities was collected by a randomized work sampling method; patients were observed from outside patient rooms; and opinions of staff and patients were collected using surveys and interviews. For the study reported in Alalouch et al. (2009), participants were asked to complete a questionnaire on privacy and to select preferred and disliked locations on plans of nursing units. Spatial data were provided by Visibility Graph Analysis (VGA) of space syntax. For the study reported in Zborowsky et al. (2010), qualitative data regarding the effects of nursing station design on nurses' health and work environment were gathered by means of focus group interviews, and quantitative data-gathering techniques included

space use observations, patient visibility assessments, sound level measurements, and an online questionnaire regarding perceptions of the work environment. For their study, Watkins et al. (2012) used questionnaire surveys, work sampling data, and design charrettes.

Some of the findings reported in these studies in relation to unit layouts are as follows: (1) Due to travel advantage and visual contact, the radial or circular units may produce better utilization of time and it may be more liked by users than the rectangular units, either of the two common linear designs - the double corridor and single corridor (Sturdavant, 1960; Trites et al., 1970). (2) A universal preference for spatial location of privacy may exist across culture, age and gender (Alalouch et al., 2009). (3) Previous spatial experience may result in specific significant difference for spatial location of privacy (Alalouch et al., 2009). (4) Nurses on centralized and decentralized units frequently perform similar duties but the time spent on these duties may be significantly higher in the centralized nursing stations. (5) Consultations with medical staff and social interactions can be significantly less frequent in decentralized nursing stations (Zborowsky et al., 2010). (6) Sound levels measured in nursing stations generally exceed recommended levels during all shifts regardless of unit layout type (Zborowsky et al., 2010). (7) No significant differences may exist in nurses' perceptions of work control-demand-support in centralized and decentralized nursing station designs (Zborowsky et al., 2010). (8) Documentation at the main nursing station can contribute to increased walking distances for nurses, and can pull the nurses away from patient rooms (Watkins et al., 2012). (9) Medication storage near the nursing station can be associated with more distractions during medication administration (Watkins et al., 2012).

Studies in simulated settings

Many simulations using physical mockups also provide good examples of psychosociotechnical studies on the relationships of behavior, psychology, and culture. However, with only a few exceptions (examples, Clipson and Wehrer, 1973; Marans, 1993), these studies generally focus on the design of patient rooms or other individual spaces, such as toilets, in nursing units (examples, Battisto et al., 2003;

Bell, 2007; Dunston et al. 2011; Hignett & Evans, 2006; Hignett & Lu, 2007; Hignett et al., 2010; NHS, 2005; Pati et al., 2008, 2010; Watkins et al., 2008). Therefore, a thorough review of this literature was not warranted for this paper that focuses mainly on studies involving nursing unit layouts.

Whether done at the unit level or room level, most studies in simulated settings generally use a multimodal approach combining the benefits of full-scale mockups with photographic and video analysis and scenario simulations. The requirements of the multitude of users are also reflected in the measures and response formats of these studies, which include questionnaires, interviews, focus group discussions, behavioral observations, walkthroughs by users and design experts, as well as the activities performed by the potential users. Therefore, research with physical mockups behavioral, psychological, and project- and organization-specific concerns, in addition to contributing to our knowledge base of nursing unit layout design. Concerning unit layout and design, one limitation of most simulation studies with physical mockups is that even in the cases where a mockup for the whole unit was built, the performance of the unit was not evaluated with the same degree of rigor as the patient rooms in the units. The costs associated with a full-scale mockup of a unit may be one important reason for this limitation.

DISCUSSION & CONCLUSION

A literature map showing the distribution of studies on nursing unit layouts by research orientations and their subcategories defined based on research methods is provided in **Figure 3**. It can be observed that studies on nursing unit layouts are well spread over several categories. Very few research studies with social and psychosocial orientations indicate immediate research needs of these categories of research on nursing unit layouts. However, this observation should not imply that the numbers of studies in the other categories of research orientation are sufficient. With only a few exceptions, many issues of nursing unit layouts are investigated no more than one time in any one category of research orientations. More studies

on these issues would be necessary for further validation of the findings that had been reported in the literature.

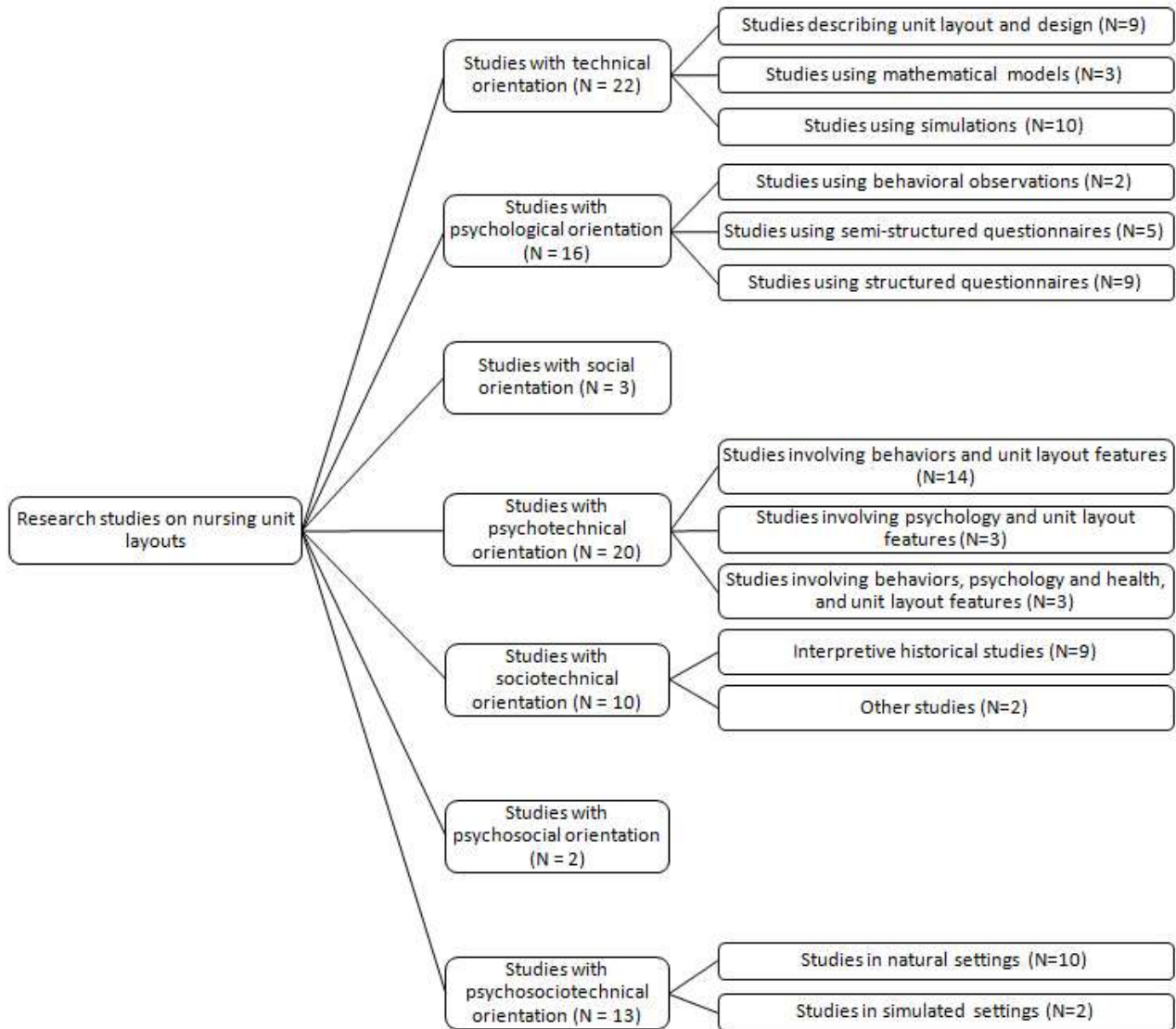


Figure 3: A literature map showing the distribution of studies by research orientations and their subcategories defined based on methods.

Seemingly important issues that have not been studied enough include patient and family behavior and psychology in different units. As we are moving more toward patient-centered healthcare design, understanding patient and family behavior and psychology in relation to unit layout and design would become increasingly important for the optimum design of healthcare environments.

Another seemingly important issue that has been studied less is health outcomes in relation to unit layout and design. More studies are needed on the health benefits of different unit layouts: Does staff stress vary in units with different types of layouts? Do infection rates, patient fall, staff injury, patient length of stay, or patient medication intake vary in units with different types of layouts? As healthcare demand and costs keep rising, unit layout must be considered an important factor for improving health outcomes. That is because unit layout is an important strategic design choice made to help organize functions and services in a nursing unit.

Yet other seemingly important issues that have not been studied enough are social and psychosocial factors in relation to unit layout and design. Concerning the social, we know very little about how unit layout affects the social and cultural life of users in the unit. There is some indication in the literature that new units may show increased hostility and decreased sociality among patients, but would the degree of hostility or sociality vary among nurses or patients in units with different layouts? Likewise, whether it is individual interaction with a social environment or it is how social patterns affect individuals, very little has been done on the psychosocial issues in nursing units in relation to layouts. One wonders if, for example, nurses would be able to cope with work stress in one type better than another type of unit layout. The research literature on nursing unit layouts posits some positive indications for this, but not enough.

In the case where several studies investigate the same issue, these studies show different concerns on the issue. For example, nurse travel on units is one of the more commonly studied issues. However, studies on the issue focus on different things including the techniques describing nurse travel on the unit; all travels made between beds, between beds and supply points, and cross-journeys; all travels undertaken by nurses in completing the various aspects of their work; movements and activities during medication administration; and so on. Since these studies are often done in different settings using different research designs, a theoretical generalization is not yet possible even for issues such as nurse travel that has been studied several times.

Concerning research strategy, comparative studies involving different unit layout types— radial vs. rectangular units, centralized vs. decentralized units, small vs. large units—have been used most frequently to investigate differential effects of layout types on the character and quality of the designed environment as well as on behavior, psychology, health and culture. These comparative studies are relatively easy to do, are done in less time, and are less expensive than any controlled experimental design. Yet, these comparative studies provide valuable insights concerning design, behavior, psychology, health, and culture in units with different layouts.

Despite their usefulness, one point to note here is that simplicity and economy can easily compromise the qualities and explanatory abilities of comparative research studies if researchers are not careful. That is because studies done quickly at minimum costs may lack accepted criteria for design assessment, sensitive methods for measuring the criteria, and information about factors that may significantly affect the measurement of the criteria. For example, researchers may be eager to assume that radial nursing units provide better visibility and accessibility than rectilinear units, but such an assumption may be proven wrong in the field where visibility and accessibility often depend not only on the geometry of a layout but also on materials, furniture, fixture and equipment. Likewise, researchers may be eager to take any categorical differences between open-plan layouts, semiprivate room layouts and private room layouts as self-evident. However, close scrutiny may reveal that differences in layout types are often better described as differences in degrees than categories. Consequently, studies based on faulty assumptions may not help establish precise relationships between specific design factors and behavior, psychology, and health in nursing units.

Another point to note here is that when comparative studies use convenience sample to save time and money, they may lack necessary controls in terms of research design. For example, comparative studies, such as the ones investigating the effects of layout changes, may overlook the fact that significant layout changes are often accompanied by organizational changes. By the time any new changes are put in place, patient groups, nursing composition, technology availability, and/or care delivery models in the unit

might have also changed significantly. Comparative studies that fail to take into account these organizational changes may wrongly attribute the effects of these changes to layout changes. They may also be unable to detect any interaction effects of organizational changes on the relationships between layout changes and behavior, psychology, health, and culture.

Yet another point to note here is that the effects of layout changes on behavior, psychology, health, and culture are not always straightforward as many amongst us would like to believe. For example, layout changes can have differential effects on different behaviors, and some changes may improve one behavior but worsen another. Likewise, a change in unit layout that may be positive for patients may not be as positive for the staff and may even conflict with staff needs (Shumaker and Pequegnat, 1989; Winkel and Holahan, 1985).

The final point to note here is that all comparative studies of nursing unit layouts are case specific. It is almost impossible to replicate the experience of a case in another case for several technical, social, economic, and geographic reasons. For example, several studies reviewed above have reported that radial units performed better than rectangular units in terms of patient and staff outcomes due to better visibility and accessibility. Yet, conditions in no two radial or rectangular units in these studies were the same. Therefore, while the findings of each study remain valid in its context, it is not possible to generalize the findings for all other radial and rectangular units, because it is not known if all radial units must have better visibility and accessibility than all rectangular units.

For any or all the above reasons, theoretical generalization may become difficult based on any number of comparative studies on nursing unit layouts. Studies that show some promise for theoretical generalization, however, are those that use various measures of spatial centrality to explain behavior, psychology, health and social outcomes in nursing units. Since these studies use rigorous techniques and measures to quantify visibility and accessibility within units of different geometry, size and functions, they are less context-dependent. However, the number of these studies remains insufficient. They are also

quite narrow in scope. Either they use only one or two case studies; or they look at a very narrow set of behaviors. Therefore, more studies are needed before any theoretical generalization is possible regarding the effects of spatial centrality on behavior, psychology, health and social outcomes.

To conclude, it must be noted here that this review covers a narrow set of studies on nursing unit layouts. Yet, the contributions of the review to the healthcare design and research areas are important. It provides a framework for integrative literature review based on research orientation. The framework is less specific without being too general. It focuses at a level that is sufficiently sensitive to identify significant variations in research, and to provide concrete guidance concerning the strengths and limitations of the strategies and tactics of research. Using the framework, the review has shown what has and has not been done in research studies on nursing unit layouts. Using the framework, the review has also overcome the limitations outcome-, research-, or paradigm-based review. It is hoped that others would use the framework to organize the literature in other areas of healthcare design research to identify areas where further research is needed, and to help raise awareness on the status of knowledge among all those interested in healthcare facility design, planning, and research.

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