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A Systematic Literature Review of Empirical Studies on Decentralized Nursing Stations

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Abstract

Objectives: The objective of this systematic review of literature was to critically evaluate peer-reviewed evidence regarding the effectiveness of decentralized nurse stations (DNSs). **Background:** The DNS has become an important topic in healthcare design research and practice over the past decade with aims of improving staff efficiency and patient experience. Research has shown to be inconclusive, with studies reporting an assortment of mixed findings. **Method:** A systematic review of literature was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses search process of electronic databases, citation tracking, and manual searches of references. All authors evaluated the studies independently. Studies included were empirical, peer-reviewed investigations of DNS in hospitals over the past 15 years. Each study was evaluated using an accepted healthcare design evaluation framework. **Results:** Over 200 studies were identified. After exclusions, 21 studies published since 2003 were available for full evaluation. Key findings from this review include (a) there is a positive trend toward patient experience in units with DNS, (b) nursing teamwork was perceived to decline in units with DNS, (c) methodological issues may be responsible for the mixed and inconsistent findings, and (d) there is no consistent categorization of nurse station typology or standard definition for DNS. **Conclusions:** Based on the evaluation framework, DNS are supportive of the patient experience yet have a negative impact on nursing teamwork. Higher quality studies are needed to classify specific typologies of DNS and account for elements such as patient care models, communication, visibility, and other patient care–related factors.

Keywords

healthcare design, systematic literature review, decentralized nurse station, hybrid nurse station, nurse station typology, patient experience, teamwork, communication, efficiency, patient outcomes

The decentralized nurse station (DNS) has become an important topic in healthcare design research and practice over the past decade (Fay, Carll-White, Schadler, Isaacs, & Real, 2017; Guarascio-Howard, & Malloch, 2007; Hamilton, 2017; Hamilton, Swoboda, Lee, & Anderson, 2018; Joseph, 2006; Stichler, 2017). Innovations in information and communication technology have made it possible to design hospitals where

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nurses and other providers no longer need to work in close physical proximity to other providers. Currently, the DNS is defined as "one or more support spaces provided at multiple (two or more) locations on a physical inpatient unit" (Pati, Harvey, Redden, & Summers, 2015, p. 57) or "smaller workstations and charting substations located closer to or inside patient rooms" (Zborowsky, Bunker-Hellmich, Morelli, & O'Neill, 2010, p. 2). In practice, the term "decentralized" has been variously referred to in the literature as recessed alcoves outside patient rooms, subnurse stations, pod clusters, multihub design, mobile stations (carts on wheels), neighborhoods, or charting substations. Additionally, the effectiveness of the DNS has appeared to have inconsistent outcomes across studies. Hence, a systematic review is necessary to provide a clear framework to compare the findings of these studies and evaluate the level of evidence regarding DNSs to inform future research and practices.

Background and Significance

Nurse stations are important to healthcare design research and practice because they are physical sites where nursing staff work and interact with other nurses, physicians, patient families, other medical/hospital staff, students, administrators, and others. Additionally, nurses do important work at their stations, such as documentation of patient care plans, charting, and coordinating care responsibilities, all of which impact patient care delivery processes (Guarascio-Howard & Malloch, 2007; Hendrich, Chow, Skierczynski, & Lu, 2008; Pati et al., 2015; Zborowsky et al., 2010). Traditionally, the design for nurse stations has been a central location used by all nurses and related caregivers in a particular unit (Guarascio-Howard & Malloch, 2007). The centralized nurse station design typically includes space for charting, documentation, mentoring, formal meetings, and private spaces for informal interactions or breaks. As hospitals have moved to the use of smaller, DNSs, studies show a host of advantages and disadvantages.

The design of DNSs has been considered advantageous for a number of reasons. First, locating nurses closer to the patient enables them to be more accessible to patients and provide better care. Second, research indicates that nurses in DNSs spend more time on patient care, building community with patients and their families, preventing falls, and improving patient safety (Fay et al., 2017; Guarascio-Howard & Malloch, 2007; Hendrich et al., 2008). The simultaneous shift to larger hospitals with private rooms was thought to reduce walking distance. However, research has shown to be inconclusive, with studies reporting an assortment of mixed findings. Studies have reported increased walking in decentralized units (Ferri, Zygun, Harrison, & Stelfox, 2015; Pati et al., 2015; Real, Bardach, & Bardach, 2017) and decreased walking (Copeland & Chambers, 2017; Fay et al., 2017; Hua, Becker, Wurmser, Bliss-Holtz, & Hedges, 2012).

Studies show that nurse station design influences the quality and degree of communication, efficiency, patient care delivery, teamwork, and satisfaction (Fay et al., 2017; Guarascio-Howard & Malloch, 2007; Hua et al., 2012; Real, Fay, Carll-White, Isaacs, & Schadler, 2018). Learning and mentoring are important as nurses often work in settings characterized by unpredictability, missing information, changing processes, and irregular access to resources (Ebright, Patterson, Chalko, & Render, 2003). Nurses are more likely to help one another and turn to each other for information and assessments of patients when nurses work in close proximity (Fay et al., 2017; Zborowsky et al., 2010). However, Zborowsky, Bunker-Hellmich, Morelli, and O'Neill (2010) and Real, Bardach, and Bardach (2017) found that nurses feel a greater sense of isolation with reduced social interaction and opportunities for learning in the decentralized model. If the physical environment reduces visibility, there may be reduced opportunities for nurses to support one another (Cai & Zimring, 2012; Real et al., 2017; Trzpuc & Martin, 2010; Zborowsky et al., 2010).

Research Objective

The objective of this article is to present a systematic review of the literature of peer-reviewed, empirical studies of the DNS over the past 15 years to evaluate the effectiveness of DNS. In

alignment with the PICOS model, this research focused on evaluating how a DNS design intervention is conceptualized and the impacts of various typologies of DNS on participants such as patient and staff through systematic literature review (SLR). It aims to address the following questions: (1) What is the general level (quality and magnitude) of evidence in various thematic areas (i.e., patient outcomes, staff efficiency, teamwork, and environmental quality) related to various typologies of decentralized nursing station design? and (2) What measures exist for examining the effectiveness of the DNS?

Method

A systematic review should adhere to a standardized methodology in searching, filtering, reviewing, critiquing, interpreting, synthesizing, and reporting findings obtained from multiple publications (Pati & Lorusso, 2018). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009) Guidelines was adopted as the basis for systematic data extraction, analysis, and reporting (Moher et al., 2009). The four stages of searching following the PRISMA flowchart included identification, eligibility, screening, and included publications. Additionally, this article has been outlined in alignment with the 27 PRISMA (2009) checklist to ensure consistency and breadth of information.

The review was conducted by an interdisciplinary team of three architecture, interior design, and communication scholars from two universities as "SLRs work best when the team has at least three members, where disagreement between two members is resolved by a third member" (Pati & Lorusso, 2018, p. 4). All three researchers had previous experience conducting data and reporting research related to decentralized nursing stations. No protocols were submitted at the time of initial publication.

Identification of Relevant Literature

Relevant articles were identified through a search of PubMed, Web of Science, and CINAHL online databases. Publications were considered for these years due to the newness of this design model. It should additionally be noted that other databases including Avery and Art Index were searched based on recommendation of a reference librarian, but using the identified search terms, returned zero findings. Preliminary searches began in November 2017 to investigate appropriate search terms and concluded in March 2018. The three independent researchers used BOOLEAN search with the combination of key words and alternates for decentralization and hybrid nursing unit design. Alternative terms for decentralized included "hybrid," "pod," "alcove," and "hub," and alternative terms for "Nurs* unit" included "inpatient unit," "ICU," "intensive care unit," "med/surg unit," "acute care unit," and "Nurs* station." In addition to key word searches, hand searches of review articles were conducted in subject-related journals such as *Environment and Behavior* and *Health Environments Research & Design Journal*, and referenced articles were completed to search for additional relevant articles.

Eligibility

Studies were included in the review if they were peer-reviewed, written in English between 2003 and 2018 and empirically evaluated a decentralized and/or hybrid nursing unit and the associated physical environmental features. Studies were excluded if they (1) focused on theoretical investigations of decentralized nursing stations, (2) were opinion articles, (3) were simulation studies without on-site data collection, or (4) were not empirical. The relevance of the study evaluations was conducted by all three authors and discussion meetings were held until consensus was met. No gray literature was included such as nonpeer-reviewed publications, dissertations, or thesis. All three authors read the articles, and any issues that arose were resolved through discussion between the reviewers.

Screening

The initial database key word search identified 209 studies (Web of science yielded 73 results,

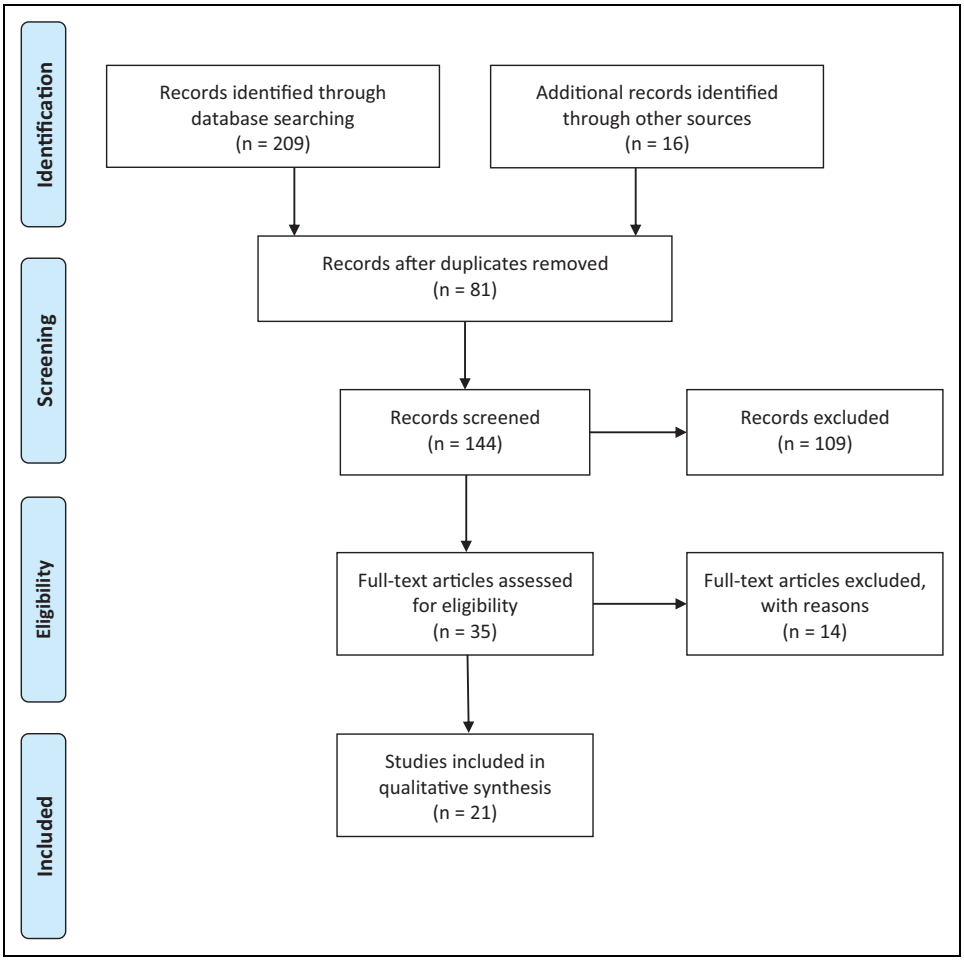

Figure 1. Preferred reporting items for systematic reviews and meta-analyses 2009 flow diagram.

PubMed generated 104 results, and CINAHL generated 32 results). An additional 16 articles were found through hand search and citation mining. The results were exported into an Endnote file. After removing 81 duplicated results, 144 studies were included for title screening. The title screening yielded 38 results for abstract review. After the abstract screening, 35 articles were assessed for eligibility. The full screening process has been illustrated using the PRISMA flowchart for literature search and selection (see Figure 1).

Excluded Articles

In alignment with the previously noted exclusion criteria, 14 articles were excluded. Studies that were not empirical were excluded (Becker, 2007; Feiler & Stichler, 2011; Hamilton et al., 2018; Ramm, Mannix, Parry, & Gaffney, 2017; Stichler, 2012; Stichler & Feiler, 2011; Zadeh, Shepley, & Waggener, 2012), as well as simulation studies without on-site data collection (Charko, Geertsen, O'Brien, Rouse, Shahid, & Hardenne, 2016; Pati, Harvey, & Thurston, 2012), and those articles that did not focus on decentralized nursing unit study (Cai & Zimring, 2017; Gum, Prideaux, Sweet, & Greenhill, 2012; Hadi & Zimring, 2016; Hendrich, Fay, & Sorells, 2004; Nanda, Pati, & Nejati, 2015). There are important takeaways from many of these articles that should be included in the discussion of the concept of decentralization later. After screening

full text for eligibility, 21 articles were identified for inclusion in the full review.

Data Collection Process

All 21 of the full articles were obtained and thoroughly reviewed by the three authors. A number of assessment criteria were put in place to evaluate the evidence. First, based on the search, the reviewers identified concentrated themes and subthemes (i.e., efficiency, communication, teamwork, staff satisfaction, and patient outcomes) to assess outcome trends. Each reviewer examined concentrated themes related to their areas of expertise, identified those studies that addressed these concentrated themes, and reported key findings and outcome trends for each study (i.e., increase or decrease). All authors reviewed the summary of findings independently and where disagreements existed, a third reviewer acted as tiebreaker (Pati & Lorusso, 2018). All information was reported in a shared Excel document for use in the analysis.

Evaluation of Quality of Included Publications

Quality of evidence and risk of bias were evaluated guided by methods developed by Stichler (2010), Pati (2011), and Taylor and Hignett (2014). Using Pati's (2011) and Stetler's (2002) framework for evaluating evidence, the 21 full articles were evaluated based on five assessment domains: purpose and overall method, sampling, research design, measurements, and analysis (see Table 1). An evaluation table was created for reviewers to assess each article based on these domains and subsequently provide a level of classification. Following Pati (2011) and Stetler (2002), each article was first assigned a numerical rating for level of evidence from one to eight to more clearly classify the articles' research designs. In this SLR, two of the eight levels of evidence emerged including Levels 4 and 6. Level 4 research studies are quasi-experimental designs that might include single experiments without random assignment or a single before-and-after study. Level 6 research includes non-experimental studies such as correlational descriptive research and qualitative research. In healthcare design research, many studies fall under comparative case study or cross-sectional studies and are not included in the examples provided in Pati's (2011) framework. These studies were classified as Level 6 in this review's rating system. Risk of bias was also evaluated based on selection, performance, detection, attrition, reporting, and other bias (Higgins & Green, 2011).

After each study was assigned a numerical rating for level of evidence, the reviewers evaluated the quality of evidence and provided a letter

Table 1. Assessment Criteria Domains for Quality of Evidence.

Assessment Domain	Grading Criteria
Purpose and overall method	Was there a fit between the research question and each progressive piece of the methodology?
Sampling	Did the sample match the research question?
	For qualitative studies, were sufficient examples, experiences, or other information obtained?
Research design	Did the design match the research question/hypothesis?
	For qualitative research, was there a clear methodology, such as grounded theory?
Measurements	Was the validity and reliability of the tools and the data collection process addressed and acceptable?
	For qualitative data, is there any way to confirm the researcher's interpretations (e.g., did they use the subject's validation?)?
Analysis	Do the interpretations of the researcher go beyond what the data support?
	For a qualitative study, can one logically follow the researcher's data analysis?

Note. Adapted from Pati (2011) and Stetler (2002).

Grade (A–D). Letter grades were determined by evaluating each of the five assessment domains equally and providing an average letter grade score for the piece of literature. All three authors independently evaluated the studies and assigned numerical and letter grade scores. Subsequently, discussion occurred among the reviewers and where necessary, consensus was determined for the final rating of evidence.

Results

Trends of Study and Study Characteristics

Notably, 16 of the 21 empirical studies were published after 2012, which indicates increasing interests in evaluating the effectiveness of the decentralized nursing unit design. Settings for the various studies included 4 in the intensive care unit (ICU), 13 in acute care units, and 4 conducted in a combination of acute care, progressive, and ICU settings. Almost all studies (20 of the 21) that reported the design typology of the decentralized units were based on the racetrack layout with varying levels of decentralization. The hybrid layout, which included a centralized team station with nursing alcoves immediately outside patient rooms, was the primary setting for 13 of the included studies. Six studies were based on multihub studies, and Zborowsky et al.'s (2010) study examined a mix of a multihub design and a decentralized unit with nursing alcoves in-between each pair of patient rooms (see the Online Appendix Table A1).

The quasi-experimental research design was applied for 12 studies and 9 studies were nonexperimental, which included 3 cross-sectional and 3 comparative case studies. In terms of research methods, 16 studies applied mixed methods that combined qualitative and quantitative approaches, 3 studies applied qualitative methods, and 2 studies applied quantitative methods. The level of evidence and research quality of each study is reported in Table 2. Detailed findings were grouped into key themes related to patient and staff outcomes including walking, time with patients, communication, teamwork, staff satisfaction, visibility, acoustics, patient outcomes, and patient satisfaction (see Table 3).

Walking

Fay, Carll-White, Schadler, Isaacs, and Real (2017) indicate that a number of factors contribute to caregiver efficiency including nursing station design and location and the impact of the physical layout on walking. One of the hypothesized benefits of DNSs was a decrease in walking. However, the review of literature revealed mixed outcomes. A total of nine studies evaluated the impact of decentralized nursing stations on staff walking distances. Of the nine studies that measured walking, three found the decentralized model to increase walking distances (Ferri et al., 2015; Pati et al., 2015; Real et al., 2017) and six reported decreased walking distances (Copeland & Chambers, 2017; Donahue, 2009; Fay et al., 2017; Grimes, Meilink, & Meilink, 2017; Hua et al., 2012). Ratings for six of the nine studies that measured walking were a Level 4A or B research study, indicating a high level of evidence for this issue in the field of healthcare design. Measurements of walking were captured primarily by pedometers and reported in either steps or miles. For example, Copeland and Chambers (2017) implemented pre–post pedometer data collection that included day and night shifts. Their data recorded number of hours worked, total patients assigned, and total steps taken per shift. Their outcomes revealed significant reductions in nurses' "energy expenditure" and steps taken with mean steps taken per shift dropping from 8,281.6 to 8,093.4. Hua, Becker, Wurmser, Bliss-Holtz, and Hedges (2012) also used pedometers to measure nurse walking distance. They found that after the move, nurses walked significantly less with average steps taken totaling 11,211 in the pre-move study and 10,226 post-move. In contrast, Pati, Harvey, Redden, and Summers (2015) found an increase in staff walking distance. Pedometer measurements from this study indicated significant increases across two of the three units with one unit increasing from 2.05 to 3.79 miles per 12-hr shift and another increasing from 2.84 to 3.50 per shift. While pedometers were the most often utilized tool for capturing walking distances, other methodologies included quantitative modeling, proximity indexes, and questionnaires. In a study conducted

Table 2. Level of Evidence and Research Quality.

Study	Purpose	Sampling	Research Design and Methods	Measurements	Analysis and Findings	Quality Rating
Bayramzadeh and Alkazemi (2014)	Explore the relationship between nursing station design and use of communication technologies by comparing centralized and decentralized nursing stations (DNSs)	Seventy registered nurses completed the survey	Nonexperimental, cross-sectional study; quantitative	Internet-based survey among registered nurses. Questionnaire comprised of five sections. Two sections referenced previous literature	Descriptive statistics and one-way analysis of variance (ANOVA) were used to analyze the survey results. No statistically significant difference between the use of communication technology in hybrid versus centralized nursing units	6-C
Cai and Zimring (2012)	Investigates whether spatial qualities of nurses' assigned alcoves affect frequency of interaction and awareness of surrounding environment and peers	Two subunit floor plans, 56 sets of behavior mapping, and 3,986 events	Quasi-experimental natural experiment study; mixed methods	Space syntax analysis for visibility, awareness network analysis for co-awareness, and communication were collected using behavior mapping	Inferential statistical analysis including *t* test and one-way ANOVA was used to reveal the strong correlation between the spatial metrics and nurses observed behaviors and co-awareness	4-A
Copeland and Chambers (2017)	Assess differences in RN walking, energy expenditure, and job satisfaction between centralized and decentralized nurses' stations	Twenty six RNs pre-move Thirty five RNs post-move	Quasi-experimental pre–post design; mixed methods	Pedometer data, open-ended questionnaire, and patient fall data	Article includes implications for practice. Significant reductions in nurses' "energy expenditure" and steps taken postrelocation. Patient falls decreased by 55%. RNs reported teamwork suffered in DNS and poor communication in both types	4-A
Donahue (2009)	Implement a pod design to address dissatisfaction with wasted steps and energy by nursing staff	Nursing staff (not specified)	Quasi-experimental pre–post design; Quantitative	Spaghetti diagrams, pedometer measurements, Press Ganey patient satisfaction surveys	The pod design for patient care assignments has improved patient satisfaction by increasing the visibility and accessibility of nurses and has enhanced nurses' ability to provide safe and reliable care. This care assignment design has also improved staff vitality by reducing the number of unnecessary steps nurses take during a shift	4-C

(continued)

Table 2. (continued)

Study	Purpose	Sampling	Research Design and Methods	Measurements	Analysis and Findings	Quality Rating
Fay, Carll-White, Schadler, Isaacs, and Real (2017)	Analyze the impact of decentralized and centralized design layouts on the delivery of efficient care and resultant level of caregiver satisfaction	Survey 45 pre-/98 postobservations 48 hr pre-/68 hr post, pedometer ($N = 24$)	Quasi-experimental pre–post design; Mixed methods	Observations, visibility, time in room, distance walked, and surveys	Article includes implications for practice. Descriptive analysis for walking distances, allocation of time and room usage, and visibility. *T* test for the staff satisfaction. The centralized design was rated significantly higher in its ability to support teamwork and decreased staff walking distances. The DNS has higher visits to and time spent in patient rooms	4-A
Ferri, Zygun, Harrison, and Stelfox (2015)	The objective of this study was to describe end user impressions and experiences in a new intensive care unit (ICU) built using evidence-based design	Thirty nine ICU end users (healthcare providers, support staff, and patient family members) 24 Phase 1 15 Phase 2	Multiphase case study in two-phase, post: 2–3 months and post: 12–15 months; qualitative study	Interviews with 39 ICU end users, 24 in the early phase and 15 in the late phase	Thematic analysis. Four themes were identified: atmosphere (abundant natural light and low noise levels), physical spaces (single occupancy rooms, rooms clustered into clinical pods, medication rooms, and tradeoffs of larger spaces), family participation in care (family support areas and social networks), and equipment (usability, storage, and providers connectivity)	6-B
Friese et al. (2014)	A medical/surgical unit at the University of Michigan Health System implemented a pod nursing model of care to improve efficiency and patient and staff satisfaction	Patient outcomes were collected monthly between July 2008 and May 2009 Survey distributed to 48 nurses and 19 nurses responded	Quasi-experimental pre–post design; multimethod	Patient satisfaction was measured with Press-Ganey. Call lights were recorded by the system per month, and falls were obtained by incident reporting system Nursing satisfaction was measured with a 5-item paper questionnaire	Three patients (satisfaction, call lights, and falls) and nurse (satisfaction and overtime) outcomes improved after implementation	4-B

(continued)

Table 2. (continued)

Study	Purpose	Sampling	Research Design and Methods	Measurements	Analysis and Findings	Quality Rating
Grimes, Meilink, and Meilink (2017)	To explore the impact of the decentralized station on the medical/surgical environment, the team conducted a postoccupancy evaluation (POE) of the Penn Medicine Chester County Hospital	Clinical staff, administrative leadership, and facilities department personnel (not specified)	Cross-sectional POE with baseline study; mixed methods	Assessed satisfaction levels of caregivers and patients through survey questionnaires and Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) scores. On-site observations of each of the four units for time and motion	Patients can recognize the differences in care from the staff and show this with a double-digit increase in HCAHPS scores. Staff reported spending extra time with their patients, increased levels of satisfaction, and up to a 71% reduction in walking distances and travel times when they spent more time at the decentralized stations	6-C
Guarascio-Howard and Malloch (2007)	To find if it is more affective to have a centralized nursing station with limited technology or highly technological DNSs	Shadowed 4 nurses with a total of 32 hr of time per design and follow-up interviews were conducted on these four nurses	Comparative case study; mixed methods	Observation, shadow, and follow-up interview. Shadow logs and interviews	Included patient satisfaction survey. Decentralized design showed more prompt patient calls than centralized nursing unit. Patients perception weights the benefits of a decentralized nursing unit higher than the disadvantages	6-A
Guarascio-Howard (2011)	A medical–surgical unit in a Southwestern United States hospital examined the results of adding wireless communication technology to assist nurses in identifying patient bed status changes and enhancing team communication	Four RNs were shadowed for 8 hr (32 hr total) before and after the introduction of wireless devices	Quasi-experimental pre–post design; mixed methods	Shadowing: patient room visits. The nurse call system: response times to patient calls, bed status calls. The wireless device system: the call initiator, number of calls, and total time of the call	Results indicate that caregiver team efficiency increased because of decreased response time to patient calls and bed status alarms. The increase in room visits and communication events among team members and hospital staff facilitated team communication, efficiency and can potentially improve care quality	4-B
Hua, Becker, Wurmser, Bliss-Holtz, and Hedges (2012)	To describe the relationship between the clinical spatial environment and its effect on communication patterns, nurse satisfaction, distance walked, organizational outcomes, patient safety, and patient satisfaction	Survey: 31 completed pre-move and 68 post-move. Shadow: 10 RNs for 30 hr. Pedometer: 25 nurses pre-move and 11 nurses post-move. Interview: 20 pre-move and 18 post-move	Quasi-experimental pre–post design nonrandomized; mixed methods	Qualitative and quantitative: survey, interview, observation. Patient satisfaction surveys, nursing team surveys, clinical work measurement tool, pedometer, nurse interviews, and organizational data.	Article includes implications for practice. Significant increase in time and frequency of nurse–doctor communicating/day. Strong increase in patient satisfaction. No significant change in job satisfaction, patient falls, pressure ulcers, or organizational outcomes (i.e., length of stay/patient census)	4-A

(continued)

Table 2. (continued)

Study	Purpose	Sampling	Research Design and Methods	Measurements	Analysis and Findings	Quality Rating
O'Hara et al. (2017)	To describe the interactions (formal and informal) and macrocognitive functions in a neighborhood design using space syntax constructs (openness, connectivity, and visibility)	Members of the clinical, operational, and therapeutic ancillary groups were all included in the observations Observations: 15 total Focus groups: 21 total	Ethnographic; mixed methods	Macrocognition: observation and focus groups; Visibility: space syntax constructs analysis, panoramic photographs, and ethnographic data	Well-designed neighborhoods of the PICU are those in which all three of the space syntax constructs (openness, connectivity, and visibility) are present, facilitating both formal and informal interactions and macrocognition	6-B
Parker, Eisen, and Bell (2012)	The purpose of the study was to determine the effect of the nursing unit design on stress and job satisfaction	Forty nurse participants Two focus groups	Cross-sectional; mixed methods	The Perceived Stress Scale and Demand-Control-Support Questionnaire were used to evaluate staff stress, job satisfaction, and perceptions of work environment	Results suggest that the centralized floor lends itself to better patient access and professional communication. Further research is needed regarding nurse burnout and turnover as it relates to the designed work environment	6-C
Pati, Harvey, Redden, and Summers (2015)	To examine the impact of decentralization on operational efficiency, staff well-being, and teamwork on three inpatient units	Survey: 110 nurses, 31 support staff pre-move and 85 nurses, 24 support staff, post-move. PDA data, and pedometers were collected continuously over 2 weeks for both shifts	Quasi-experimental pre–post design; mixed methods	Survey of staff communication and collaboration, acute stress, presenteeism, teamwork, perceived walking distance, and patient safety. Actual walking distance was measured using pedometers. PDA: time and motion	Article includes implications for practice. Inferential statistical analysis. Data demonstrate that decentralized nursing and physical design models potentially result in quality of work improvements associated with supplies. However, there are unexpected and unintended consequences associated with walking, staff communication, collaboration, and interaction	4-A
Rashid, Khan, and Jones (2018)	To compare whether staff perception and their associations with physical and visual accessibilities change in the slightly modified racetrack ICU and moving from an open ICU to a pod design	Before: RN 61 Charge nurse: 9 Physician: 2 Others: 9 Total: 81 After: RN 39 Charge nurse: 7 Physician: 1 Others: 3 Total 50	Quasi-experimental pre–post design; mixed methods	Data on physical and visual accessibilities collected using the spatial analysis techniques of Space Syntax, and the data on staff perception collected using a questionnaire survey	Inferential statistical analysis. The physical and visual accessibilities of the racetrack unit did not change, but less clinicians reported to know their peers in the second phase compared to the first phase. After moving from an open ICU to a pod design, both the physical and visual accessibilities and staff perception of co-awareness improved	4-A

(continued)

Table 2. (continued)

Study	Purpose	Sampling	Research Design and Methods	Measurements	Analysis and Findings	Quality Rating
Real, Bardach, and Bardach (2017)	The purpose of this study is to qualitatively investigate how the built environment impacts communication, patient care processes, and patient outcomes. We draw upon systems theory and healthcare professionals' insights to investigate DNSs in a new hospital	Nine focus groups interviews were conducted with 35 healthcare professionals from 10 provider groups	Quasi-experimental pre–post design; mixed methods	Focus groups interviews to collect users' perception of the design and impacts on communication. Quantitative modeling to assess walking distances in two different hospital designs	Systematic qualitative analysis. 1. DNSs changed system interdependencies by reducing nurse-to-nurse interactions and teamwork while heightening nurse interdependencies and teamwork with other healthcare occupations. 2. Many nursing-related processes remained centralized while nurse stations were decentralized, creating systems-based problems for nursing care. 3. Nursing communities of practices were adversely affected by the new design	4-B
Real, Fay, Carll-White, Isaacs, and Schadler (2018)	This study utilizes systems theory to understand how changes to physical design structures impact communication processes and patient and staff design-related outcomes	Progressive, acute, ICU unit nurses ($N = 26$ pre-move, $N = 51$ post-move) Patients ($N = 62$ pre and $N = 49$ post)	Quasi-experimental pre–post design; mixed methods	Communication and teamwork measured through survey. Patient outcomes measured through EMR and survey	Article includes implications for practice. Patients preferred the decentralized units. Nurses approved the patient rooms, unit environment, and noise levels in decentralized units. However, they reported reduced access to support spaces, lower levels of team/mentoring communication, and less satisfaction with design than in centralized units	4-A
Real, Santiago, Fay, Isaacs, and Carll-White (in press)	This pre–post multimethod study explored how nurses made sense of changes in nurse station design and how they characterized communication processes within a hospital unit before and after it moved from centralized to decentralized units	Observations (116 hr) of interactions collected in both designs. 41 nursing staff participated in eight qualitative focus groups	Quasi-experimental pre–post design; mixed methods	Quantitative observations (116 hr) of real-time communication across both designs. Focus groups interviews for RNs' insights of designs and impacts on teamwork and communication	Observational data resulted in two key findings: first, nursing staff participated in about 70% of interactions. Second, nursing communication decreased in decentralized units. Systematic qualitative analysis revealed nursing communication was more frequent, relational, and supportive in centralized spaces while characterized by fragmentation and information exchange in decentralized units	4-A

(continued)

Table 2. (continued)

Study	Purpose	Sampling	Research Design and Methods	Measurements	Analysis and Findings	Quality Rating
Trzpuc and Martin (2010)	To determine how the design of decentralized medical–surgical nursing units influences nurses' communication and, subsequently, perceived social support	Two nurses, one health coordinator, and three medical unit floor plans	Exploratory comparative case study; qualitative	Visibility and connectivity were analyzed using space syntax constructs. Semistructured interview was used to collect nurses' perception of DNS on team communication and social support	Article includes implications for practice. Thematic analysis was conducted on interview. Found difficulty reaching consensus in preference for NS type. The design of nursing station whether centralized or decentralized should consider visibility and accessibility to optimize team work	6-C
Zborowsky, Bunker-Hellmich, Morelli, and O'Neill (2010)	To investigate how nursing station design (i.e., centralized and DNS layouts) affected nurses' use of space, patient visibility, noise levels, and perceptions of the work environment	A convenience sample of six nursing units located in three U.S. hospitals was selected for the study	Exploratory comparative case study; mixed methods	Perceptions of the work environment: focus group interviews and questionnaire. Noise: sound-level measurements. Interaction and time spent at activities collected by place- and person-centered space use observations. Visibility: patient visibility assessments	Found a reduced level of interaction and collaboration among staff. Time spent using telephones, computers, and performing other administrative duties were significantly higher in the centralized nursing stations. No significant differences were identified in noise, visibility, nurses' perceptions of work control–demand–support in centralized, and DNS designs	6-A
Zhang, et al. (2015)	To explore nurses' experiences with communication and teamwork at the hybrid station and to examine nurses' perceptions of advantages and disadvantages of the hybrid station	A convenience sampling method. Twenty nursing staff participated in the key informant interviews	Phenomenology case study; qualitative	Twenty interviews were completed with nursing staff members who were undergoing a transition from the centralized design to the hybrid station design	Thematic analysis. Challenges: perceived isolation, communication, and teamwork are compromised on hybrid unit. Scattered assignments reduced benefit of hybrid model. Benefits: reduced distraction, better time management, more quiet, and better proximity to patients	6-B

Note. RN = Registered Nurse; PICU = Pediatric Intensive Care Unit; PDA = Personal Digital Assistants; EMR = Emergency Medical Response.

Table 3. Concentrated Themes With Trends.

Study	RN–RN Comm.	Physician–RN Comm.	Total Comm.	Teamwork	Staff Satisfaction	Time at Nurses' Station	Time in Patient's Room	Visits to Patient Room	Walking	Patient Outcomes	Patient Experience and Satisfaction	Visibility	Acoustics
Bayramzadeh and Alkazemi (2014) (6-C)	+		+			−	+	+					
Cai and Zimring (2012) (4-A)	+		+	+								+	
Copeland and Chambers (2017) (4-A)	−			−	±				−	+		+	
Donahue (2009) (4-C)							+		−		+		
Fay, Carll-White, Schadler, Isaacs, and Real (2017) (4-A)				−	±	+	+	+	−			−	
Ferri, Zygun, Harrison, and Stelfox (2015) (6-B)	±	±	+	+	+				+			−	+
Friese et al. (2014) (4-B)		−	−		±		+		−	+	+		
Grimes, Meilink, and Meilink (2017) (6-C)					+		+		−		+		
Guarascio-Howard and Malloch (2007) (6-A)	−	±	+	−			+	+			+		+
Guarascio-Howard (2011) (4-B)	+		+	+				+		+	+		
Hua, Becker, Wurmser, Bliss-Holtz, and Hedges (2012) (4-A)	±	±	±	−	±				−	±			

(continued)

Table 3. (continued)

Study	RN–RN Comm.	Physician–RN Comm.	Total Comm.	Teamwork	Staff Satisfaction	Time at Nurses' Station	Time in Patient's Room	Visits to Patient Room	Walking	Patient Outcomes	Patient Experience and Satisfaction	Visibility	Acoustics
O'Hara et al. (2017) (6-B)	±	+	+	+								+	
Parker, Eisen, and Bell (2012) (6-C)	−		−	−	−								
Pati, Harvey, Redden, and Summers (2015) (4-A)	−	+	−	−		−			+				
Rashid, Khan, and Jones (2018) (4-A)				±								+	
Real, Bardach, and Bardach (2017) (4-B)	−	+	±	±	±				+		−	−	
Real, Fay, Carll-White, Isaacs, and Schadler (2018) (4-A)	−		±	−	±						+		
Real, Santiago, Fay, Isaacs, and Carll-White (in press) (4-A)	−	±	−	−	±								
Trzpuc and Martin (2010) (6-C)	−		−		±							−	
Zborowsky, Bunker-Hellmich, Morelli, and O'Neill (2010) (6-A)	−		−	−	−							±	±
Zhang et al. (2015) (6-B)	±		±		±								

Note. Number of studies per grading identified as: + = supportive of decentralized nurse stations; − = not supportive of decentralized nurse stations; ± = equivocal.

by Real et al. (2017), walking distances of staff members were measured through quantitative modeling by measuring nurse walking distances between the nursing stations and patient rooms and through qualitative analysis of focus groups. Results indicated a significant increase in walking and increased perception of walking among nurses in the decentralized unit.

Time With Patients

The allocation of nurses' time spent at the nurse station or with the patient was also found to be a consistent method across several studies for examining efficiency. Caregiver time spent with the patient was measured by six studies (Bayramzadeh & Alkazemi, 2014; Donahue, 2009; Fay et al., 2017; Friese et al., 2014; Grimes et al., 2017; Guarascio-Howard & Malloch, 2007). Time was primarily captured through observations or shadowing of nursing staff with documentation of time noted as nurses entered or left patient rooms. All of these studies reported an increase in time in the decentralized model. Nursing staff visits to patient rooms were measured by three studies (Bayramzadeh & Alkazemi, 2014; Fay et al., 2017; Guarascio-Howard & Malloch, 2007). All three of these studies reported increased visits to patient rooms in DNS. Outcomes from the time studies extended across the breadth of the rating categories for this evaluation, but most importantly all indicated a positive trend.

Communication

Communication was measured directly in 15 studies and 2 more studies gathered evidence of communication indirectly. Of these 17 studies, there were nine mixed methods, five qualitative, and three quantitative approaches. Cai and Zimring (2012) used mixed methods and found that proximity was important: The closer the nurses were to other nursing staff, the more likely they were to communicate face-to-face. Interaction ratios developed in their study indicated that when nurses were spread out, they viewed centralized stations as communication hubs. Guarascio-Howard and Malloch (2007) used mixed methods as they shadowed and observed over 500 communication episodes. They categorized communication as one of seven types (collaboration, consult, leadership, patient information, coaching, coordination, or other) and found there were more of these specific communication types in decentralized units than centralized with the exception of patient information. Hua et al. (2012) used mixed methods to understand elements of communication such as who, when, where, and what (nature of interaction). They found few significant changes in communication patterns between different unit designs (centralized, decentralized, and multihub design). O'Hara et al. (2017) used observations, focus groups, and architecture drawing files to understand how specific locations within units created opportunities for "situated macrocognitive interactions" that occurred primarily in "neighborhoods" located at corners and islands near decentralized stations. Zborowsky et al. (2010) observed more consulting of staff, social interaction, technology use, and family contact in centralized than in decentralized stations. Real et al. (2017) used primarily qualitative methods to understand how DNSs affected face-to-face and interdisciplinary communication among 10 provider groups. Although nurses reported less nurse–nurse communication, many other disciplines reported higher levels and better-quality communication in decentralized units. Guarascio-Howard (2011) examined wireless communication technology and reported that face-to-face communication remained stable from before (77%) to after the introduction of wireless technology (75%) in decentralized units. Her study found that communication time and episodes increased 77% and 78%, respectively, in a decentralized unit, while wireless likely replaced some phone use, particularly away from alcoves. The findings of these 16 studies were inconsistent across all levels of quality (4A and B, 6A, B, and C; Table 4). Although there were no overarching conclusions from these studies, it is clear that nurse station design impacts communication in healthcare settings.

Teamwork

Teamwork was measured directly in 10 studies and 4 more studies assessed it indirectly. These

Table 4. Summary of Outcomes Based on Evidence Grading.

Outcome	4a	4b	4c	6a	6b	6c	Total × Outcome
Time with patients	1 (+)	1 (+)	1 (+)	1 (+)		2 (+)	6
Walking	1 (+); 3 (−)	1 (+); 1 (−)	1 (−)		1 (+)	1 (−)	9
Communication	3 (−); 3 (±)	1 (+); 1 (−); 1 (±)		1 (−); 1 (±)	2 (+); 1 (±)	1 (+); 2 (−)	17
Teamwork	5 (−); 2 (±)	1 (+); 1 (±)		2 (−)	3 (+)	1 (−)	15
Visibility	3 (+); 1 (−)	1 (−)		1 (±)	1 (+); 1 (−)	1 (−)	9
Acoustics				1 (+); 1 (±)	1 (+)		3
Patient outcomes	1 (+); 1 (±)	2 (+)					4
Patient experience and satisfaction	2 (+)	1 (+)	1 (+)	1 (+)		1 (+)	6
Staff satisfaction	1 (−); 4 (±)	2 (±)		1 (−)	1 (+); 1 (±)	1 (−); 1 (±)	12
Total × Grading	31	14	3	10	12	11	81

Note. Some studies may appear more than once due to multiple outcomes. Number of studies per grading identified as: + = supportive of decentralized nurse stations; − = not supportive of decentralized nurse stations; ± = equivocal.

14 studies employed quantitative, qualitative, and mixed methods. Real and colleagues (2018) used a pre–post quantitative survey design and found statistically significant lower levels of nursing teamwork communication after a unit moved from centralized to decentralized units. Zhang et al. (2015) used interviews to learn how "pod teams" were created of two nurses and one assistant working as "team buddies" within a hybrid design model connecting decentralized stations with centralized meeting spaces. Although nursing staff reported feelings of isolation, they identified patient-centered interactions at the hybrid station and learning to work as a team as advantages of the hybrid design. Hua et al. (2012) used their Nursing Team Collaboration Survey and found no statistical differences in teamwork between pre- and post-move or between a control group and the moved groups. Social interaction declined: in qualitative interviews after the move, nurses reported more isolation, difficulty getting help, and quantitative shadowing data backed this up, showing that social interaction declined 62% in moved units. Guarascio-Howard and Malloch (2007) indirectly inferred teamwork through observations of type of communication, such as coordination and collaboration and further, in interviews as nurses indicated teamwork was higher in centralized designs. Pati et al. (2015) employed surveys to find that staff perceived decentralized layouts to be less supportive of teamwork than centralized layouts. Real et al. (2017) used focus groups and asked 10 different provider groups about level and ease of collaboration on patient floors. Nurses indicated there was less teamwork in the decentralized model while most other disciplines asserted that it improved. As seen in Table 4, the quality of these 14 studies ranged between Levels 4A and 6C. Nearly, all of the studies were Level A ($n = 8$) or B ($n = 5$). There were eight studies in Levels 4A and B, indicating robust evidence for the effect of decentralized designs on teamwork.

Staff Satisfaction

Overall, 12 studies measured staff satisfaction. Eight studies measured staff satisfaction directly and four studies gathered evidence indirectly. The majority of these studies examined job satisfaction while a smaller number investigated satisfaction with design. Qualitative methods were used in six studies, five used quantitative, and one employed mixed methods to measure staff satisfaction. Hua et al. (2012) measured job satisfaction and found no difference between units that moved pre and post. However, satisfaction was lower for nurses who were newer (less than 3 years) compared to those who had worked longer than 3 years. Qualitative interviews conducted by Trzpuc and Martin (2010) explored nurse job satisfaction. They reported that the majority of

nurses working on a newer floor returned to the older, centralized unit after 1 year, yet some of the stated reasons were related to management and staffing issues. Pati et al. (2015) measured stress, which is an influencing factor in determining overall job satisfaction and found no differences in acute stress between centralized and decentralized units. Zborowsky et al. (2010) qualitatively examined nurse satisfaction with working conditions and reported evidence from focus groups of lower satisfaction in decentralized units. Satisfaction with design was measured by two studies. Real and colleagues (2018) investigated patients' and nurses' satisfaction with design in a pre (centralized) -post (decentralized) study. They found that patients had higher satisfaction with design, while nurses experienced lower satisfaction with design in the decentralized units. Fay et al. (2017) asked a variety of hospital staff about their overall satisfaction with design and found no differences between centralized and decentralized units. However, using comparative poststudy only questions, respondents preferred the design of the new, decentralized units over the old centralized units. The level of quality of these studies ranged between Levels 4A and 6C, and the results of these studies were inconclusive. Within Levels 4A and B, three of the six studies reported no change while two had equivocal findings where nurses felt less satisfaction while patients and other disciplines experienced increased satisfaction. These findings suggest greater attention to detail in terms of sample and focus of satisfaction questions.

Noise

Only three studies compared noise levels in decentralized and centralized layouts. Guarascio-Howard and Malloch (2007) found a slightly lower noise level in the decentralized nursing unit compared to the centralized nursing unit. This study reported no details on how noise levels were measured, the location of the sampling points, and no statistical significance were given to the comparison. Zborowsky et al. (2010) found that both centralized and decentralized nursing unit designs have exceeded the recommended levels of 45 dB(A) for continuous background noise in daytime and 35 dB(A) for nighttime set by the World Health Organization and the Occupational Safety and Health Administration. No significant reduction of noise levels was found moving to the decentralized unit from the centralized design. Zborowsky et al. measured sound levels in each nursing station using a portable decibel meter (Extech Model #407738) during all nursing shifts and shift changes, covering both high- and low-activity periods. Ferri, Zygun, Harrison, and Stelfox (2015) didn't measure the actual noise but inferred from interviewee's self-report that the noise level in the decentralized unit was reduced in the pod design compared to the traditional centralized design. The three studies that evaluated noise were rated either Level 6A or B studies, indicating weak evidence on the positive trend of reduction of noise in the decentralized nursing model.

Visibility

A total of nine studies either directly or indirectly evaluated visibility in units with decentralized nursing stations. Three studies didn't directly measure actual visibility. In Copeland's study, the authors claimed that the new design had higher visibility to patient rooms, yet no evidence was provided. Among them, two studies applied qualitative methods such as interviews to gather staff's perceived visibility (Ferri et al., 2015; Real et al., 2017). The authors reported reduced visual contact between providers, creating a barrier for collaborative communication, teamwork, and situational awareness.

Patient visibility was measured in two studies by counting the number of patient beds in direct view of the nursing station (Fay et al., 2017; Zborowsky et al., 2010). In addition to patient visibility, Fay et al. (2017) measured peer line of sight. The results were inconsistent. Zborowsky et al. (2010) found no difference in terms of visibility in the centralized and decentralized units, while Fay et al. (2017) found that both patient and peer visibility decreased in the decentralized nursing unit when compared to the old centralized layout. Either space syntax constructs or related measures for evaluating visibility were utilized across four studies. In Trzpuc and

Martin's (2010) study, visibility and accessibility space syntax theory constructs were applied to evaluate a decentralized medical–surgical nursing unit to validate the anticipated benefits of better visibility and accessibility associated with DNS. The visibility analysis was conducted based on descriptive annotation on the floor plans without conducting quantitative space syntax analysis. Nurses' perception of the visibility and accessibility didn't conform with the results inferred from the descriptive annotations. O'Hara and her colleagues (2017) used three space syntax constructs (openness, connectivity, and visibility) to evaluate the impacts of an ICU with "neighborhood" or multihub design on macrocognition. The visibility measurement was based on isovist views, with a 360 field of vision from nurses' stations into patient rooms. These were compared to panoramic photos to assess visibility between patients and interprofessional team members. By using observation and focus group data to interpret the relationship of the three space syntax constructs to macrocognition, they found that when all three attributes are present, the design facilitates both formal and informal situated macrocognitive interactions.

Cai and Zimring (2012) developed their measures based on the space syntax constructs of step depth calculated using the Depthmap software (version 10) team-base distance and peer distance. The team-base distance measured the visual and metric step depth from each alcove to the team station, and the peer distance measured the average visual and metric step depth from one nurse alcove to all the other peer alcoves. The spatial metrics demonstrated a strong correlation to nurses' distribution, interaction, and co-awareness. The overall number of rooms that a nurse is aware of patient status was positively correlated to the global integration value of their alcove. Nurses assigned to alcoves with lower peer step depth were found to have a significantly higher interaction ratio and better co-awareness of other patients' condition and peers' location. Rashid et al. (2018) utilized axial map analysis to collect data on physical accessibilities and visibility graph analysis to collect data on visual accessibilities using Depthmap software. They found that the new pod-designed ICU was visually more accessible but physically less accessible than the previous open-plan ICU. Clinicians' awareness of their coworkers and their locations improved as a result. Overall, the direction of change of visibility in decentralized nursing units was inconsistent. Although quality of evidence, measurement of visibility, and outcomes varied among these nine studies, there was a strong correlation between visibility and staff communication, co-awareness, and macrocognition.

Patient Outcomes

Only four studies measured patient outcomes in association with decentralized nursing units. All of them measured patient fall rates as the patient safety outcome. For instance, Guarascio-Howard (2011) and Copeland and Chambers (2017) compared patient falls before and after moves and found a decrease post-move. In addition to fall rates, Friese et al. (2014) collected the total number of call light use on a monthly basis between July 2008 and May 2009 and found a decrease in use of call lights in the poststudy. Hua and colleagues (2012) assessed the clinical outcomes such as patient outcomes and organizational outcomes. For patient safety, the study aggregated data for total number of patient falls per 1,000 patient days and also compared occurrence of hospital-acquired pressure ulcers before and after the move. Using data obtained from the Hospital Quality Assurance database, they measured several indices of organizational outcomes: (a) percentage of beds occupied, (b) average census, (c) average length of stay, and (d) number of patient days. No significant changes were found between the centralized and decentralized designs. Real et al. (2017) didn't specifically measure patient outcomes but instead asked clinicians to report their perception of care quality in the decentralized unit design; nurses reported a decrease in perceived care quality, while other clinical professionals perceived an improvement in care quality. All of the studies were Level 4A or B studies, which demonstrates credible evidence that the decentralized nursing unit could improve patient outcomes.

Patient Experience and Satisfaction

Patient experience and satisfaction in the decentralized nursing unit was evaluated in six of the studies. The majority (5 of the 6) examined patient satisfaction using the widely adopted instruments of the Press Ganey and Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) surveys. Three studies found that the decentralized unit scored higher on the question "Promptness in response to call" in Press Ganey (Donahue, 2009; Guarascio-Howard & Malloch, 2007; Hua et al., 2012). Hua and colleagues (2012) also found other measures of patients' perceived nursing care quality to improve in the new multihub layout including "nurse attitude toward patient/family requests," "being informed by the nurses," and "pain control." Similarly, Donahue (2009) found the pod design (equivalent to multi-hub) to have a positive impact on nurses' promptness in response to calls, attention to their personal needs, ability to keep the patient informed, and overall care in Press Ganey as well as reduced incidences of patient complaints. Grimes et al. (2017) compared the average score of HCAHPS in a centralized and three new decentralized hybrid units and found an improvement in patient satisfaction in the decentralized model. Interestingly, Friese et al. (2014) reported the overall nursing care satisfaction from the Press Ganey survey improved after shifting to a pod model from a hybrid design with a team station and distributed nurse servers outside each patient room. One study developed its own questionnaire to gather patients' experience before and after moving from a centralized unit to a decentralized unit (Real et al., 2018). This study included questions regarding patients' perception of their room, communication with staff, privacy and confidentiality, ability to get help from staff, and their satisfaction with design. The results indicated that patients preferred decentralized units because of the larger single-occupancy rooms, greater privacy/confidentiality, and overall satisfaction with design. It is worth noting that some of the perceptions of decentralization, such as a larger room, are separate and only partially related to the decentralized concept. Although the quality of these six studies varies across the spectrum between Levels 4A and 6C, all studies demonstrated a trend of positive change in patient experience after moving to some level of decentralization. Among them, three units have a hybrid design and three have a multihub design.

Discussion

Overall, the 21 studies included in this review of literature emphasize the need for higher quality evidence to support more consistent findings in the examination of decentralized nursing stations. The literature for this SLR assessed nine outcome variables including walking, time with patients, communication, teamwork, visibility, acoustics, patient outcomes, patient satisfaction, and staff satisfaction. Of the nine outcome variables, three emerged as predominant foci in "total by outcome" of the examined literature including communication, teamwork, and staff satisfaction. These three outcomes variables additionally represent the strongest evidence of the nine categories. Notably, three understudied outcomes involved the patients: time with patients, patient outcomes, and patient experience and satisfaction, with all studies reporting positive trends (Table 4). Acoustics was revealed to be the lowest outcome variable with only three studies focusing on noise levels in DNS and all three were rated a Level 6 study. Of the 78 total outcomes that were measured, 45 were rated 4A, B, or C across 12 studies (Cai & Zimring, 2012; Copeland & Chambers, 2017; Donahue, 2009; Fay et al., 2017; Friese et al., 2014; Guarascio-Howard, 2011; Hua et al., 2012; Pati et al., 2015; Rashid et al., 2018, in press; Real et al., 2017, 2018, in press) and 33 were rated 6A, B, or C across 9 studies (Bayramzadeh & Alkazemi, 2014; Ferri et al., 2015; Grimes et al., 2017; Guarascio-Howard & Malloch, 2007; O'Hara et al., 2017; Parker, Eisen, & Bell, 2012; Trzpuc & Martin, 2010; Zborowsky et al., 2010; Zhang et al., 2015). The concentration of literature in category six, which includes such research as correlational descriptive research or single noncausal studies, suggests that efforts should be made to advance the quality of evidence surrounding the topic of DNSs. The challenge, however, will be to ensure not only that research

achieve scientific strength and quality but also usability to support design decisions.

An important outcome from this review is the positive trend toward patient experience in decentralized nursing units. Although outcomes revealed that more studies should examine aspects of the patient experience including time spent with patients, patient outcomes, and patient satisfaction, those studies that did examine these issues reported positive trends. Outcomes from all six of the studies that measured time spent with patients found that more time is spent at the patient bedside or in patient care in the decentralized model. These are important findings because, when nursing staff spend more time in patient rooms and increase visits to patient rooms, less time is spent waiting in medication and supply rooms and instead, more time can be spent monitoring patients (Guarascio-Howard & Malloch, 2007). Additionally, the decentralized model was found to positively impact patient outcomes across three Level 4A and B studies, which demonstrates credible evidence that the decentralized nursing unit can contribute to improved patient outcomes. Patient satisfaction was also found to be a common positive outcome of the review. Of the six studies that measured patient satisfaction, three units implemented a hybrid design and three have multihub; all six reported positive trends. Four of these articles were rated Level 4 studies suggesting there is credible evidence to support the relationship of hybrid or multihub designs and patient satisfaction. It should be noted that the number of studies in this theme is small and thus, future studies should examine patient outcomes in decentralized nursing units to further validate the evidence.

Outcomes from all six of the studies that measured time spent with patients found that more time is spent at the patient bedside or in patient care in the decentralized model.

A second finding was that teamwork was perceived to decline in decentralized nursing units (Copeland & Chambers, 2017; Fay et al., 2017; Guarascio-Howard & Malloch, 2007; Parker et al., 2012; Pati et al., 2015; Real et al., 2018; Zborowsky et al., 2010). This finding should be a concern for hospitals, as the Institute of Medicine, Kohn, Corrigan, and Donaldson (2000) and the Joint Commission (2008) have identified teamwork as an important element in patient care quality and safety. Teamwork did not decrease in all studies yet the majority of the eight studies in grading Level A found a negative trend: six studies reported a negative relationship, one study found mixed results, and another found no change in the relationship between teamwork and DNSs. Hospital executives and healthcare designers may want to consider these findings when deciding to develop decentralized models. However, the greater part of grading Level B studies found a positive relationship between teamwork and decentralized designs. These results suggest that greater attention may be paid to research design, conceptualization, and measurement in future research. Similarly, few studies reported staffing models, which are important to teamwork, thus making it hard to infer future design decisions.

A third finding of this review involved the extent to which methodological issues may be responsible for the variety of mixed results and inconsistent findings. Communication is a good example of how different conceptualization, measurement, sampling, and design characteristics can lead to different results. Communication was conceptualized and measured in a variety of ways, from frequency to satisfaction to specific types of communication (e.g., mentoring) to more open-ended, qualitative perspectives aimed at in-depth understanding. Sampling varied widely, ranging from a focus on nursing staff only to investigating up to 10 different healthcare disciplines. Design characteristics were diverse as well, ranging from decentralized station/alcoves outside patient rooms, decentralized stations across the hallway from patient rooms, hybrid, multihub, and pod designs. Communication was not alone in having mixed results. Visibility study results were also inconsistent. Among existing studies, six units applied the hybrid design, two applied the multihub design, and one has both hybrid and multihub design. It is worth noting that other factors in addition to the DNS, such as the shape of the unit, the length of the corridor, the location and transparency of the support core, and the height of furniture and partitions, can all

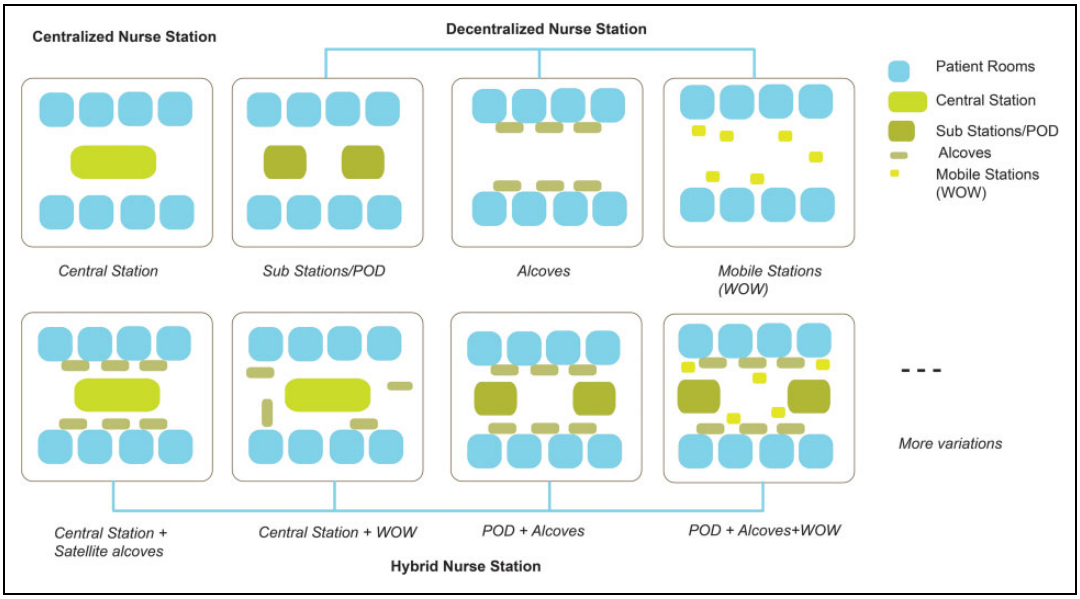

Figure 2. Decentralized nurse station typologies.

impact visibility of the unit (Hadi & Zimring, 2016; Hamilton et al., 2018). More studies that use rigorous quantitative space syntax measures to examine the visibility in various decentralized nursing unit typologies are needed to corroborate these findings. As research in nursing station design advances, more consistent research designs and measurements are needed.

The SLR reveals that there is no consistent categorization of nurse station typology or standard definition for decentralized nursing stations. This lack of reliable conceptualizations of this important design element makes it difficult to locate the findings of individual studies within the larger framework of nurse station research. Cai and Zimring (2012) defined four basic components of a nurse station typology: central station, subnurse station/pod, alcoves, and mobile workstations or workstation on wheels (WOWs). In practice, there are various combinations of those components (Figure 2). For instance, the fully decentralized model can include distributed alcoves, WOWs, or multihub designs that locate subnurse stations in smaller clusters of patient rooms, which have also been referred to as clinical pods or neighborhoods. The hybrid model refers to the combination of these components, such as a central team station (predominantly for interdisciplinary team members) and distributed alcoves, a central team station and WOWs, a multihub design with distributed alcoves, a multihub that includes both alcoves and WOWs, and many other variations. However, these combinations are currently simplified as DNS typologies.

Limitations and Future Work

This SLR focused on peer-reviewed, empirical studies written in English. Hence, the article cannot fully represent the application of decentralized nursing units in other cultural contexts, nonempirical studies, or research not reported through academic journals. Additionally, the search for this systematic review applied many alternative terms to capture articles related to DNS, but due to the inconsistency of the definition of DNS, some studies that apply decentralization might not be captured by the current search terms. This SLR applied Pati's framework for measuring the quality of evidence, as it is accepted by the healthcare design field. It is recognized that the adoption of other evidence assessment instruments such as the Center for Evidence-Based Medicine and Grading of

Recommendations, Assessment, Development, and Evaluation from the medical research field may lead to different rating results.

This SLR has suggested the need for more, higher quality studies to examine the impacts of decentralized nursing units on patient and staff outcomes. Experimental or randomly assigned studies and more quasi-experimental studies that collect pre- and postdesign interventions of DNS are needed in this area. Future studies should focus on applying existing, validated instruments or develop rigorous measures for efficiency, teamwork, and visibility (Hadi & Zimring, 2016; Zadeh et al., 2012). There is a need to create a consistent definition of the DNS typology, and clear reporting of the typology with different levels of decentralization and relationship among these key components in future research. Doing so will allow researchers and practitioners to better understand the findings of research surrounding these models and identify the most effective measures associated with the typology. It is worth noting that the existing studies included in this review predominantly implement either multihub or hybrid models that combine a central station with distributed alcoves. It will be increasingly important that future studies examine other degrees of decentralization as the models continue to adapt. Finally, theory is an important consideration. The DNS is a system structure that influences the processes and outcomes in healthcare settings (Real et al. 2017, 2018, in press). Systems theory is useful for understanding how nursing stations operate within complex systems comprised of many components, including built environment, department/unit, staffing, information technology, organizational culture, nursing care model, and more.

Conclusions

This is the first systematic review of literature focused on the concept of DNSs. The objective of this review was to critically evaluate peer-reviewed evidence regarding the effectiveness of DNSs. Over 200 studies were identified using the PRISMA search process and 21 peer-reviewed, empirical studies were included in the final review of literature. There were four major findings from this review. First, there is a positive trend toward patient experience in decentralized nursing units. Second, nursing teamwork was perceived to decline in decentralized nursing units. Third, methodological issues may be responsible for the mixed and inconsistent findings. Fourth, there is no consistent categorization of nurse station typology or standard definition for decentralized nursing stations. Future research should aim to include more experimental or randomly assigned studies and the development of a consistent definition of the DNS typology. In order for healthcare designers and researchers to better understand the effectiveness of the DNS, more rigorous research designs are needed that consider additional factors such as the patient care model and organizational culture.

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Implications for Practice

- Decentralized nursing stations are supportive of the patient experience.
- Decentralized nursing stations have a negative impact on nursing teamwork.
- Hybrid and hub models reported positive trends relative to patient experience.
- Satisfaction with design may be a useful proxy measure for general patient satisfaction.
- Understanding the proper balance between proximity, efficiency, visual surveillance to patients, peer-to-peer visibility, and sense of privacy and sense of community is important.
- Higher quality evidence is needed to identify specific typologies of DNS and account for elements such as patient care models communication, visibility, and other relevant factors.

- Studies should provide unit demographic tables in order for researchers and designers to gain a better understanding of context.

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