

# Environment and Behavior

## Beyond Co-location: Visual Connections of Staff Workstations and Staff Communication in Primary Care Clinics

Journal:	<i>Environment &amp; Behavior</i>
Manuscript ID	E&B-19-0305.R2
Manuscript Type:	Original Manuscript
Keywords:	visibility, communication < Content Areas, teamwork, team-based, primary care
Abstract:	<p>The importance of communication among healthcare providers has been long recognized, and many healthcare organizations are implementing team-based care, with emphasis on staff communication. While previous empirical studies in various settings illustrate the role of built environments in user communication, there is a lack of quantified interpersonal spatial metrics to predict interactions. This study investigates how interpersonal spatial metrics at different scales predict staff communication patterns by empirically studying four primary care clinics that provide team-based care. We found that staff members in clinics with higher visual connections among staff members reported more timely and frequent communication. We also found that staff members talked to each other more frequently when their workstations were visually connected. The findings of this study are expected to help designers and facility managers provide well-designed team-based clinic layouts, beyond just shared work spaces for team members, for improved staff communication.</p>

SCHOLARONE™  
Manuscripts

## VISIBILITY AND COMMUNICATION

1

## Abstract

The importance of communication among healthcare providers has been long recognized, and many healthcare organizations are implementing team-based care, with emphasis on staff communication. While previous empirical studies in various settings illustrate the role of built environments in user communication, there is a lack of quantified interpersonal spatial metrics to predict interactions. This study investigates how interpersonal spatial metrics at different scales predict staff communication patterns by empirically studying four primary care clinics that provide team-based care. We found that staff members in clinics with higher visual connections among staff members reported more timely and frequent communication. We also found that staff members talked to each other more frequently when their workstations were visually connected. The findings of this study are expected to help designers and facility managers provide well-designed team-based clinic layouts, beyond just shared work spaces for team members, for improved staff communication.

*Keywords:* visibility, communication, teamwork, team-based, primary care

## VISIBILITY AND COMMUNICATION

2

**Introduction**

Teamwork is critical in most healthcare settings, including primary care settings (Delva, Jamieson, & Lemieux, 2008; Jesmin, Thind, & Sarma, 2012; Shoemaker et al., 2016). Many healthcare organizations are implementing team-based care in their outpatient care models (Kennedy & Nordrum, 2015; Schottenfeld et al., 2016; U.S. Department of Veterans Affairs, n.d.), and more than 12,000 practices are providing team-based care with Patient-Centered Medical Home recognition (National Committee for Quality Assurance, n.d.).

Communication, a core and trainable skill for teamwork (Alonso et al., 2006; Wauben et al.; 2011), is critical for safety and quality of patient care (Alonso et al., 2006; Barach & Weinger, 2007; Ellingson, 2002). Ineffective communication is identified as the main cause of medical errors in ambulatory care settings (Carson-Stevens et al., 2016; Elder & Dovey, 2002; McDonald, Luke, Jude, Madden, & Chan, 2012; Webster et al., 2008). While much attention has been given to electronic clinical communication, face-to-face interaction continues to play significant a role in healthcare settings (Brown et al., 2009; Coiera, 2000; Gharaveis, Hamilton, Pati, & Shepley, 2017; Kilner & Sheppard, 2010; Reddy & Spence, 2008).

Built environments regulate spatial relationships among users and influence their face-to-face interactions as illustrated in an extensive body of research; however, most studies were conducted in traditional office settings (Allen, 2007; Heerwagen, Kampschroer, Powell, & Loftness, 2004), and only a limited number of studies have examined clinical communication in healthcare settings (Gharaveis, Hamilton, & Pati, 2017; Peavey & Cai, 2018). Furthermore, while many studies have found that layout facilitates communication among staff members, it is hard to separate the role of specific design strategies—such as proximity or visibility—due to the lack of quantified spatial metrics for collaborative facility design. Filling this gap, this study

## VISIBILITY AND COMMUNICATION

3

identifies specific spatial metrics that define interpersonal spatial relationships among users and investigates how the identified spatial metrics predict staff communication patterns in team-based primary care clinics where staff communication is of importance. As part of a larger study investigating the role of clinic design on teamwork experiences, including teamwork perceptions (Lim, Kanfer, Stroebel, & Zimring, 2019b) and backstage communication (Lim, Kanfer, Stroebel, & Zimring, 2019a), this study focuses on staff communication patterns.

**The Role of Built Environments in Communication**

The role of facility design, as part of a larger healthcare system, has been advocated for supporting organizational performance and individual experiences, including staff interactions (Larry, David, Suzan, Susan, & Frank, 2003; Peavey & Cai, 2018). Previous empirical studies illustrate the role of interpersonal spatial properties—mostly visual relationships—on communication at multiple physical scales across both clinical and non-clinical settings.

**Overall layout.** Findings from non-clinical settings (e.g., research/academic or office settings) reported that overall layouts where users can easily see and access the entire space (i.e., layouts with higher integration values) are positively associated with a higher mean useful contact rate (Penn & Hillier, 1992), perceived usefulness of other employees (Sailer, Budgen, Lonsdale, Turner, & Penn, 2007), and more frequent face-to-face interactions (Rashid, Wineman, & Zimring, 2009; Sailer et al., 2007, 2009; Wineman & Serrato, 1997).

For clinical settings, there is a limited number of studies investigating how overall unit layout predicts staff communication. Lu and Seo (2012) found that a radial-like intensive care unit (ICU) with better visibility was associated with more frequent staff interactions compared to a racetrack ICU unit. Freihoefer, Kaiser, Vonasek, and Bayramzadeh (2017) reported more frequent communication in an onstage/offstage clinic layout that separates patients from staff

## VISIBILITY AND COMMUNICATION

4

compared to the clinic layout with exposed staff work areas. Karp et al. (2019) observed more frequent communication within the care team in the onstage/offstage clinic layout compared to the pod-based clinic layout with private provider offices.

**Spatial properties of specific locations.** Many previous studies in non-clinical settings show that the attributes of specific areas (e.g., shared staff spaces, corridors) can predict communication patterns (Boutellier, Ullman, Schreiber, & Naef, 2008; Penn, Desyllas, & Vaughan, 1999; Rashid, Boyle, & Crosser, 2014; Wineman & Adhya, 2007). For example, Wineman and Adhya (2007) found that locations that are connected more to other corridors supported higher perception of interaction support. Workspaces that have accessible shared team spaces or meeting rooms show more frequent brief interactions (Boutellier et al., 2008).

In clinical settings, multi-hub designs in medical/surgical floors (Hua, Becker, Wurmser, Bliss-Holtz, & Hedges, 2012), and a “health team hub” with an adequate level of privacy in rural hospitals (Gum, Prideaux, Sweet, & Greenhill, 2012), facilitated more frequent, spontaneous conversations among staff members. Recent studies in primary care settings have focused on the role of “co-location” in staff communication. Individuals co-located in the same space show more face-to-face interaction (Gunn et al., 2015; Karp et al., 2019), more communication and collaboration (Bolstad, Cuevas, Gonzalez, & Schneider, 2005), and higher team development scores (Stroebel et al., 2019). Also, having accessible shared space in general practices was associated with more frequent informal communication (Pullon, Morgan, Macdonald, McKinlay, & Gray, 2016).

**Workstation relationships.** Lastly, several studies in office settings have found that spatial attributes of workstations (i.e., relationships between workstations, relationships between workstations and overall spaces) predict communication patterns. Higher “intervisibility”

## VISIBILITY AND COMMUNICATION

5

between workstations (Markhede & Koch, 2007) and higher visible co-presence (the number of people visible from a path of observation within the visual field from an axial line; Rashid, Kampschroer, & Zimring, 2006) were associated with more frequent face-to-face interactions.

For inpatient settings, studies have reported that caregivers in centralized nurse stations communicated with each other more frequently compared to decentralized nurse stations (Gurascio-Howard & Malloch, 2007; Pati, Harvey, Redden, Summers, & Pati, 2015; Real, Bardach, & Bardach, 2017; Zborowsky, Bunker-Hellmich, Morelli, & O'Neill, 2010). Also, more frequent interactions in an ICU unit were reported at workstations requiring a lower average number of steps to other nurse workstation alcoves (Cai & Zimring, 2012).

**Interpersonal Visual Relationships and Staff Communication in Primary Care Clinics**

Previous studies provide useful design implications, and visibility (e.g., ability to see overall area, specific spaces, or coworkers' workstations) seems to play a critical role in communication patterns in various scales and settings, including primary care clinics. However, they lack the spatial metrics that enable quantitative implementation and evaluation of interpersonal spatial relationships between users (i.e., healthcare staff). Furthermore, the previous findings in healthcare settings leave an important question unanswered: what is it about "co-location" in team-based primary care clinics (or centralized nurse stations and hubs in inpatient settings) that enables better communication of staff members?

**Design attributes.** The two seemingly critical design mechanisms of co-location or cluster of workstations are proximity and visibility. Proximity refers to physical closeness between people in space (Hall, 1966), and visibility is the ability to see (or be seen by) other people, space, or targets in space (Lim, Kim, & Zimring, 2019). People located nearby are more likely to share their work and to coordinate better, and people are reminded of their potential

## VISIBILITY AND COMMUNICATION

6

communication partners when they can see them, prompting frequent communication (Allen, 2007).<sup>1</sup> While both design attributes seem to play critical roles in facilitating staff communication, this study focuses on visibility as a main design attribute of various design strategies (e.g., co-location and team hubs) due to the nature of the study settings: team-based primary care clinics have shared team spaces that provide a certain level of proximity between staff members.

**Research questions.** The purpose of this study is (1) to introduce new spatial metrics to measure interpersonal visual attributes that go beyond co-location of staff members and (2) to investigate the role of the identified spatial metrics in supporting staff communication. More specifically, this study postulates that staff members will perceive having more timely and frequent communication in clinics with higher visual connections among staff members, communicate more frequently at highly visually connected areas within each clinic, and talk to each other more often when their workstations are visually connected.

### Methods

#### Settings

This study empirically studied four primary care clinics from two healthcare systems X and Y, which advocated for team-based primary care (Table 1). In order to explore specific design variables beyond having shared spaces for improved communication, this study selected from each organization two clinics that had physical team spaces shared by clinic staff members—including providers—and covered a range of arrangements of the shared team spaces. Beyond the team-oriented approach and shared team spaces, the four clinics differed in other ways, including size, organization, culture, and available technology. Accordingly, the findings

## VISIBILITY AND COMMUNICATION

7

of this study reflect an opportunity to investigate multiple clinics that share two key characteristics (i.e., team-based care values and common team spaces).

**Context of care.** The four clinics provided primary care—the patient’s first point of entry for health care—including health promotion, disease prevention, and longitudinal treatment of chronic illness. Unlike the inpatient setting, the majority of work in the primary care outpatient clinic is routine or semi-urgent, variable in complexity, and responsible for the health outcomes of large numbers of patients both during and between visits. All four clinics delivered team-based care, and the core team consisted of primary care providers (physician, nurse practitioner, physician’s assistant), registered nurses, and rooming nurses (medical assistants, licensed practical nurses).<sup>2</sup> Primary care providers examined, diagnosed, and treated patients. Registered nurses delivered nurse-based visit care (immunizations, injections, blood pressure visits) and performed phone call follow-up and triage for patients. Rooming nurses escorted patients to exam rooms, obtained vital signs, and prepared patients for examination by the providers. In addition, the teams were supported by extended care members providing specialty care (nutritionists, behavioral health providers, pharmacists, care coordinators), call nurses (licensed practical nurses, patient appointment coordinators) receiving patient calls, and patient flow managers (appointment coordinators, front desk receptionists). The size of the enrolled patient population varied across clinics.

**Clinic layouts.** Clinic A had three main team spaces designated for specific roles of staff members (e.g., provider office, rooming nurse station). Though these team areas were physically separated, they were still visually connected to each other. Clinic B also separated team areas for specific roles of staff members: rooming nurse stations, provider stations, and an RN (Registered Nurse) office. These team areas were both physically and visually separated. Clinic C had one



## VISIBILITY AND COMMUNICATION

8

team area shared by all staff members. This clinic located staff members with different roles together in “pods.” While the clinic had one team area, the team area had five clusters of workspaces, with each cluster shared by a pod. The workstation clusters were visually separated by a huddle room located in the middle of the team area. Lastly, Clinic D had a large team area that located most staff members together. The team area was shared by two teams; for each team, staff members with the same role were clustered together.

**Spatial Variables: Staff–Staff Visual Relationship Metrics**

Visual relationships between staff members were assessed with three variables that use different units of analysis: clinics, spaces, and workstations.

**Visual connections of staff workstations (clinic level).** The first variable indicates how much, on average, staff members could see other staff members’ workstations in the clinic. For instance, depending on the locations and layouts of clinic and team areas, staff members may have been able to see on average 50% of other staff workstations.

**Visual connections between staff workstations and clinic spaces (space level).** The second metric was designed to assess the visual connections between staff workstations and clinic spaces (e.g., work areas and corridors). This variable shows how many staff workstations were visible at clinic areas—in other words, visual exposure level of clinic spaces.

The two visual connection variables were measured using a newly developed analysis tool, VisualPower (Lim et al., 2019). Furthering existing approaches of spatial analyses, such as visual access and exposure (Archea, 1984) and visibility graph analysis (Turner, Doxa, O’Sullivan, & Penn, 2001), this tool enables analysis of interpersonal visual relationships by quantifying visual attributes at specific locations that reflect architectural and situational environments that users experience (Lim et al., 2019). Using the VisualPower tool, the locations

## VISIBILITY AND COMMUNICATION

9

of staff workstations where staff members can be expected to dwell were preselected and represented with points (one point per seat), as origins and targets of staff visibility for the first variable and as origins of staff visibility for the second variable.<sup>3</sup> Clinic spaces beyond the controlled access points of the clinics, excluding the waiting areas, were also represented by points translated into a grid of points with 1-foot intervals in clinic areas.

**Categorical visual connection levels between role-specific workstation clusters**

**(workstation level).** The last workstation-level variable categorizes visual relationships between role-specific workstation clusters, focusing on providers, rooming nurses, and RNs as core team member roles<sup>4</sup> to explore and control the effect of roles on communication patterns.<sup>5</sup> The three staff roles generated six combinations of communication counterparts (e.g., providers-to-rooming nurses). This variable is categorically defined at three levels: workstations were “almost not visible to each other” (level 1),<sup>6</sup> workstations were “partially visible to each other” (level 2),<sup>7</sup> and most workstations could “see each other” (level 3).<sup>8</sup>

Clinics where the same roles of staff members were clustered together (Clinics A, B, and D) provided level 3 visibility between staff members with the same role; however, visual connection between staff members with different roles varied depending on the layout of team rooms.<sup>9</sup> Clinic C, on the other hand, located staff members with different roles in a pod layout, providing level 3 visibility between staff members with different roles assigned to each other.

**Communication Measurements**

Staff communication patterns were assessed using surveys and behavior mapping observations. Two visits to each clinic—a preliminary visit gathering contextual information and a data collection visit conducting surveys and observations—were made in 2017.

## VISIBILITY AND COMMUNICATION

10

**Staff survey.** As part of a larger study, the survey had a set of questions regarding their teamwork experiences after an extensive review of existing instruments. For communication perceptions, two constructs—timeliness and frequency—were included in the paper survey with an assumption that visibility of staff workstations and clinic spaces would encourage staff members to approach each other in a frequent and timely manner since they are aware of locations and activities of other staff members. For communication timeliness, four items from the ICU Nurse-Physician Questionnaire developed by Shortell, Rousseau, Gillies, Devers, and Simons (1991) were selected, and one item for communication frequency was written by the authors. All items employed a 5-point Likert scale as indicated by Shortell et al. (1991).

All available care team staff members during the visits were invited to participate in the survey. A total of 88 staff members from the four clinics answered the survey, and a total of 83 valid responses were further analyzed (response rate = 64.3%).<sup>10</sup> A factor analysis was conducted to examine the construct validity of communication timeliness and frequency, and the items were loaded on corresponding constructs. Based on the Cronbach's alpha test, timely communication items (4 items;  $\alpha = .641$ ) were found to be reliable.

**Behavior mapping observations.** The public space and workspaces of four clinics were observed using a proprietary tablet application (DuBose, Lim, & Savitsky, 2016). Each observation period included following a predetermined route and recording where each individual was, what their role was, what their posture was, whether they were talking, and what devices they were using. An observation was conducted every 10, 15, or 30 minutes, depending on the size of the clinic. No identifying personal information was collected, communication content was not recorded, and exam rooms were not observed.

## VISIBILITY AND COMMUNICATION

11

**Statistical analysis.** Data were managed in Microsoft Excel, QGIS 2.14, and SPSS 22. Statistical analysis—including descriptive statistics, Kruskal-Wallis test, and correlation analyses—was performed using SPSS 22 (IBM, n.d.).

**Results**

This study analyzed three staff visual connection variables at three different scales: clinic, space, and workstation levels. The summary results of the variables are described in Table 2, and the results of two visual connection variables at specific locations (i.e., staff workstations for the first variable and clinic spaces for the second variable) are illustrated in Figures 1–4, per clinic.

Descriptive statistics for the survey and behavioral mapping measures by clinic are provided in Table 3. According to the survey results of the 83 responses, the four clinics reported relatively high average scores for timely and frequent communication. Clinic B reported the lowest levels and Clinic D the highest levels for both communication frequency and timeliness constructs. Also, a total of 193 observation rounds were collected, and the locations of all observed staff interactions are illustrated in Figures 1–4. Using the behavior mapping observation records, the communication frequency of a specific role combination ratio (“observed interacting role-specific individuals”/“total observed role-specific individuals”) for each clinic was calculated (Table 4).

**Visual Connections of Staff Workstations and Communication Perceptions (Clinic Level)**

As illustrated in Figure 5, both frequency and timeliness of staff communication perceptions show positive linear relationships with levels of overall visual connection of staff workstations. Clinic D, with a higher visual connection level, shows higher communication perception levels, and Clinic B, with a lower visual connection level, shows lower communication perception levels.

## VISIBILITY AND COMMUNICATION

12

Mean clinic scores of the perceived communication frequency were statistically significantly different across clinics, according to the nonparametric Kruskal-Wallis H test results ( $\chi^2(3) = 24.387, p < .001$ ) with mean rank scores of 35.07, 24.60, 39.08, and 53.81 for Clinics A, B, C, and D, respectively. Subsequent post hoc pairwise comparisons using Dunn's (1964) approach with a Bonferroni correction revealed statistically significant differences in frequent communication scores between Clinics D and B (adjusted  $p < .001$ ) and between Clinics D and A (adjusted  $p = .023$ ). The clinics showed a relatively large magnitude of difference in perceived communication frequency according to the effect size ( $\eta^2 = .271$ ) of the categorical variable of the four clinics (i.e., Clinics A, B, C, and D). Further, the positive linear relationship between the staff-staff visual connection and perceived communication frequency was found to be significant,  $r = .922, p = .039$  (1-tailed).

The mean scores of the timely communication measured by the four items in the survey were found to have statistically significant differences between clinics according to the Kruskal-Wallis H test ( $\chi^2(3) = 9.901, p = .019$ ), with mean rank scores of 45.89, 24.87, 43.47, and 46.99 for Clinics A, B, C, and D, respectively. The post hoc analysis revealed statistically significant differences between Clinics D and B (adjusted  $p = .014$ ). The categorical variable of the four clinics explained only 8.7% of the total variance with a small effect size ( $\eta^2 = .087$ ). The linear relationship between the staff-staff visual connection and timely communication score was reported to be highly correlated but was not statistically supported according to the Pearson correlation analysis,  $r = .816, p = .092$  (1-tailed).

In summary, positive linear relationships were obtained between the degree of staff visual connections and perceptions of communication frequency and timeliness. Staff members in clinics where they could see more of other staff workstations reported higher perceptions of

## VISIBILITY AND COMMUNICATION

13

timely and frequent communication. The magnitude of the phenomenon was larger for communication frequency than for communication timeliness.

**Visual Connections of Staff Workstations and Observed Communication Frequencies (Clinic Level)**

While the overall staff-workstation visual connection levels were found to have positive associations with communication perceptions, no specific effect of the overall visual connection level was found on observed communication frequency. The four clinics had different types of shared team spaces in their clinic layouts. For instance, Clinic A provided physically separated but visually connected multiple team rooms, while Clinic D provided one large team space for all staff members. These layout differences resulted in a range of visual connection of staff workstations ratios between the clinics (22% to 53%). This study postulated that this varying degree of visual connections would be associated with communication frequency.

Contrary to our expectation, clinics where staff members could see more staff workstations (e.g., Clinic D with one large team room) did not have more statistically significant frequency of observed communication between staff members (Table 3). On average, 12–16% of observed core team members (providers, rooming nurses, and RNs) talked to each other in all four clinics, reporting no statistically significant differences between clinics. Furthermore, 40%, 32%, 46%, and 31% of all observed staff members talked to each other in Clinics A, B, C, and D, respectively, not showing a specific relationship with the overall visual connection levels between staff members in the four clinics.

In summary, while staff members in clinics with higher visual connections between staff workstations reported higher timely and frequent communication perceptions, neither more nor less frequent communication among staff members was observed in those clinics.

## VISIBILITY AND COMMUNICATION

14

**Visual Connections between Staff Workstations and Clinic Spaces and Observed Communication Frequencies of the Spaces (Space Level)**

We also examined the relationship between communication frequency and visual connection of workstations at clinic areas. In contrast to Rashid et al. (2006), however, we did not find a significant relationship using behavior mapping observation data. That is, observed staff communication was not more frequent in clinic areas where staff could see more staff workstations (see Figures 1–4 for locations of all observed instances of staff communication). Furthermore, staff members did not communicate more with each other at locations where they could visually access the overall clinic area or exam rooms, unlike in the ICU setting Lu and Zimring (2012) studied.

Instead, we found that staff talked near their workstations. Most observed staff communication occurred around workstations, which were not locations where more staff workstations were visible in the clinic. Furthermore, staff members mostly (76–92%) talked with each other while at least one staff member was sitting at their assigned workstation. Our results show that 92%, 78%, 76%, and 83% of observed communication involved at least one sitting staff member during the interactions in Clinics A, B, C, and D, respectively (Table 5). This finding corresponds to previous findings that a majority of face-to-face interactions (40–80%) occur at workstations (Boutellier et al., 2008; Herman Miller, 2014).

There are two possible explanations for the localized pattern of communication around workstations. First, it is possible that staff members needed to access their computers, screens, or electronic information during the interactions. The behavior mapping data revealed that 27–38% of observed communication instances involved computers, which were nearly the half of the observed instances involving at least one sitting staff member (Table 6). As noted by Luff,

## VISIBILITY AND COMMUNICATION

15

Heath, and Greatbatch (1992), screen-based systems do tend to localize staff members to those screens, constraining locations of collaborations. This finding is further supported by previous studies reporting improved communication and workflow with mobile technology (Prgomet, Georgiou, & Westbrook, 2009; Sweeney, Paruchuri, & Weingart, 2018).

Another possible reason for the workstation-centered communication is that staff members talked to each other at a close distance and away from the patient spaces (e.g., exam rooms) to ensure privacy. When a staff member was sitting at their workstation, other staff members approached them and talked at a close distance rather than talking across hallways or team areas. The average distances between talking staff members were found to be 5.24, 5.71, 4.80, and 4.79 feet in Clinics A, B, C, and D, respectively. This distance falls within the social space of individuals, near the edge of personal space (Hall, 1966). Very few interactions occurred beyond 12 feet, which represents the public distance between individuals (Figure 6).

**Visual Connections between Workstation Clusters and Observed Communication****Frequencies (Workstation Level)**

Lastly, the localized patterns of communication between staff members were further analyzed by investigating the relationship between role-specific workstation visual connections and observed communication frequency of the core team members (providers, rooming nurses, and RNs). Figure 7 plots observed communication frequency in relation to three categorical variables: clinic, specific role combination, and visual connection level. When the observed communication frequency was compared according to the three categorical variables, the only factor that reported statistically significant differences in communication frequency levels was the categorical level of visual connection between workstation clusters. No statistical differences



1  
2  
3 VISIBILITY AND COMMUNICATION 16 were observed between clinics ( $\chi^2(3) = .620, p$   
4  
5 = .892) or between specific roles of communication counterparts ( $\chi^2(5) = 10.740, p = .057$ )  
6  
7 according to the Kruskal-Wallis H tests.<sup>11</sup>  
8  
9

10 The Kruskal-Wallis H test revealed that there were statistically significant differences in  
11 frequency of communication between visual connection levels,  $\chi^2(2) = 14.632, p = .001$ , with a  
12 mean rank communication frequency of 4.83 for level 1 ( $n = 6$ ), 9.67 for level 2 ( $n = 6$ ) and  
13  
14 17.75 for level 3 ( $n = 12$ ). Furthermore, the post hoc analysis reported that the communication  
15  
16 frequency of the level 3 is statistically significantly higher than that of the level 1 (adjusted  $p$   
17  
18 = .001). The categorical visual connection levels were found to have a large effect size ( $\eta^2$   
19  
20 = .602), explaining 60.2% of the total variance.  
21  
22  
23  
24  
25

26 With these findings, a follow-up question arose: were the core team members in visibility  
27 level 3 layouts talking to each other because of their proximity to each other and not because of  
28 the visual connections? While the four clinics provide proximity between staff workstations by  
29 co-locating them on the same floor or in the shared team space, the physical distance between  
30 workstation clusters varies, which may also affect the communication patterns. The definition of  
31 the visibility levels inevitably confounds the effects of visual connection and proximity in the  
32 variable. For instance, workstations that were clustered together (level 3, “See each other”)  
33 provided both visual connections and close distance between workstations. On the other hand,  
34 workstation clusters with visibility levels 1 and 2 were mostly physically separated with other  
35 spaces or rooms in between. Only two workstation relationships were adjacently located in  
36 visibility levels 1 and 2: Provider–RN in Clinics B (level 1) and D (level 2). While the effect of  
37 proximity cannot be statistically controlled due to the limited sample size, the two instances  
38 highlight the effect of visual connections compared to that of proximity.  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## VISIBILITY AND COMMUNICATION

17

1  
2  
3  
4  
5 In Clinic B, the provider area and the rooming nurse area were located next to each other  
6  
7 with no visual connections (level 1) between workstation clusters due to a wall and a partition in  
8  
9 between. Their communication frequency ratio was low (5.0%). Rooming nurses and providers in  
10  
11 Clinics B and D who had level 1 visibility between their workstation clusters talked to each other  
12  
13 very little regardless of their proximity (Clinic B: 5.0%, adjacent; Clinic D: 4.3%, separated).  
14  
15 This instance shows that visual connection was necessary and that distance was not sufficient to  
16  
17 facilitate communication frequency between the core team members. When there were no visual  
18  
19 connections between workstations, the core team members did not talk to each other frequently  
20  
21 even when they were located next to each other.  
22  
23  
24  
25

26 Another instance in Clinic D illustrated that adjacency is not necessary. The provider area  
27  
28 and the rooming nurse area in Clinic D were adjacent to each other with partial visibility (level  
29  
30 2). Staff members of one role could see staff members of the other role at their workstations,  
31  
32 especially when they stood up. When workstation combinations that had partial visibility (level 2)  
33  
34 across clinics were compared, the adjacent clusters of providers and rooming nurses in Clinic D  
35  
36 reported the lowest frequency ratio (3.2%) compared to five other separated instances with  
37  
38 visibility level 2 in Clinics A and B (on average, 9.7%). In this limited sample, the workstation  
39  
40 clusters that were separated showed higher frequency ratio values when they had partial visibility.  
41  
42 One thing to note is that though the workstations were separated, they were on the same floor and  
43  
44 often on the same corridor. Proximity between workstations within a specific threshold (e.g., the  
45  
46 same floor, corridor, or space) is desired for more frequent communication, as previous studies  
47  
48 have reported (Allen, 1970; Bolstad et al., 2005; Gunn et al., 2015; Kraut, Egido, & Galegher,  
49  
50 1988), but putting them next to each other might not be necessary.  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## VISIBILITY AND COMMUNICATION

18

While the two instances illustrate the potential impact of visual connections between workstation clusters even with longer distance, the result of another statistical analysis shows that the visual connections between clusters were not only necessary but also increased communication frequency. Workstation clusters that were separated—but had even partial visibility—had increased communication among the core team members who were assigned to those workstation clusters. The mean communication frequency ratio values were compared between workstation visibility levels (level 1 and 2) for the clusters that were separated.<sup>12</sup> The nonparametric Kruskal-Wallis H test revealed statistically significant differences in communication frequency between visibility levels 1 and 2,  $\chi^2(1) = 3.938, p = .047$ , with a mean rank of 3.60 for level 1 ( $n = 5$ ) and 7.40 for level 2 ( $n = 5$ ).

In summary, the effect of visual connections between workstation clusters was found to be significant. Workstation clusters that had visual connections from sharing workstations or being located next to each other showed the highest communication frequency among the core team members in the workstation clusters. Staff members did not limit their communication to staff of a specific role, and they did not talk more to adjacent staff members when they did not have visual connections. Providing only adjacency between workstation clusters did not predict more frequent communication, but providing visual connections between physically separated clusters did predict more frequent communication among the core team members in the clusters.

**Discussion**

This study found that the visual relationships between staff members were strongly related to staff communication patterns. First, overall visual connection levels of staff workstations predicted communication perceptions of staff members. Clinics with higher visual connections between staff workstations showed higher perception of timely and frequent

## VISIBILITY AND COMMUNICATION

19

communication, but the visual connection levels of clinics were not associated with observed frequency of communication. It is possible that there was a discrepancy between the subjective and objective measurements that this study employed. The behavior mapping observations recorded locations of only face-to-face communication instances in the public areas and workspaces, excluding exam rooms for patient privacy. Staff members might have considered various modes of communication at all potential clinic areas, including exam rooms, while answering the survey regarding communication timeliness and frequency.

Second, observed communication among staff members was not more frequent at clinic spaces where they could see more staff workstations, overall clinic area, or exam rooms. This finding contradicts that of a previous study in an ICU that reported more frequent staff interactions at locations where staff can visually access overall clinical space and patient rooms (Lu & Zimring, 2012). It may be that the differences between the ICU practice and the outpatient clinic practice account for this contradiction. As Lu and Zimring (2012) explained, nurses and physicians in the ICU talk at locations where they can closely observe their assigned patients or the surrounding environment. While staff in the ICU setting have time-sensitive and urgent communication needs for their patients during their stay, communication in the outpatient practice is less urgent and frequently focused on patients not actually in the clinic. The more deliberate pace of communication may allow for planned, highly efficient communication encounters, thus accounting for the lack of observed difference in frequency.

Third, visual connections between workstation clusters predicted frequent communication. While observed communication was not more frequent between specific roles of staff members, or between proximate staff members without visual connections, more frequent communication was observed between core team members whose workstations were visually

## VISIBILITY AND COMMUNICATION

20

connected. Even staff members whose workstations were physically separated from each other talked more often when they were visually connected. This finding supports Markhede and Koch (2007)'s finding that workstations with higher "intervisibility" were associated with more frequent communication.

In summary, staff members did not talk more often (1) in a clinic that had higher overall visual connections of staff workstations; (2) in clinic spaces, such as corridors or exam rooms, with higher visual connections to staff workstations, overall clinic area, or exam rooms; (3) to a specific role of staff members; or (4) to closely located staff members with no visual connections. Instead, most observed communication occurred near staff workstations (specifically between staff members whose workstations were visually connected), supporting the previous findings in relation to staff co-location (Bolstad et al., 2005; Gunn et al., 2015; Karp et al., 2019; Stroebel et al., 2019), nursing/team hub design (Gum et al., 2012; Hua et al., 2012), and centralized nurse stations (Gurascio-Howard & Malloch, 2007; Pati et al., 2015; Real et al., 2017; Zborowsky et al., 2010). Further investigation of this study revealed that it is visual connections and proximity of "co-location," and especially visual connections between staff members, that facilitate frequent staff communication.

**Implications**

The results we obtained have design implications at multiple scales, from clinic layouts to internal layouts of team areas. Clinic layouts providing team areas with visually connected staff workstations would help staff members to positively perceive their communication patterns. For instance, Clinic D (which had one large team area, with a 53% ratio of visual connection of staff workstations) reported the highest communication frequency and timeliness perceptions. However, a specific clinic layout module compared to other modules (e.g., one large team room

## VISIBILITY AND COMMUNICATION

21 for

all staff members or multiple pod-concept team areas) might not generate more frequent communication.

Instead, the internal layouts of team areas and workstations have significant impacts on communication frequency. Planning the location and relationships between clusters of workstations can support communication between staff members. Staff members who need to have frequent communication for patient care would benefit from being located in workstation clusters with visual connections and close distances. For instance, if the team areas are segregated by staff type (e.g., Clinic A and B), it is possible that more frequent intra-communication would occur, assuming that staff members of the same role sharing the team room are visually connected. Also, if the team areas are segregated by a group of different roles of staff members (e.g., Clinic C), more frequent inter-communication might occur (if they are visually connected and adjacent to each other). Placing workstation clusters in close proximity with no visual connections (walls or partitions in between) will not sufficiently support frequent communication. When all workstations are separated, visual connections between the separated workstations will facilitate staff interactions.

**Limitations and Future Research Directions**

This study has several limitations. First, it did not test the directionality of the relationships in this study. For instance, while strong associations between visual connections and communication instances were reported and observed, it is hard to discard an alternative explanation that relationships drove communication, with staff sitting near other staff with whom they needed to speak. Second, only four clinics were empirically investigated. The limited sample size resulted in a lack of power in several statistical analyses, including correlation analysis. This issue also disabled further analysis, such as comparing the effect of distance and

## VISIBILITY AND COMMUNICATION

22

visual connection; only two instances support the argument. Third, the outcome measurements used in the study have some limitations. Behavior mapping observations (capturing multiple snapshots) does not lend itself to capturing the full picture of communication patterns, such as communication length. Also, communication content was not recorded during the observations (intentionally), which means the communication frequency recorded in this study cannot differentiate patient-related communication from purely social interaction.

This study did not investigate patients' experience and outcomes: it focused on staff communication patterns and visibility attributes of staff members. The presence of patients and the spatial attributes in relation to patients were not included in this study. How the presence of patients impacts staff teamwork and communication is an important topic for future studies. Furthermore, future studies investigating how spatial and visual relationships between staff members and patients predict staff-patient communications and patients' teamwork experiences are recommended.

## VISIBILITY AND COMMUNICATION

23

**Declaration of Conflicting Interests**

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

**Funding**

The author(s) received no financial support for the research, authorship, and/or publication of this article.

**Notes**

1. Refer to Allen (2008) and Peavey & Cai (2018) for an extensive review of the role of proximity and visibility on communication and collaboration in non-clinical and clinical settings, respectively.
2. In this paper, we termed nurses as registered nurses (RNs), rooming nurses, and call nurses, according to their roles. While nurses with the RN credential performed similar roles across clinics, the credentials of nurses for other roles varied across clinics. For instance, a licensed practical nurse (LPN) worked as a rooming nurse in one clinic but as a call nurse in another clinic.
3. This study analyzes the two visual connection variables using points to represent potential main locations of staff members and clinic areas. This study did not follow staff members to capture their exact locations throughout the day to quantify their actual visibility experiences.
4. While other roles of team members—such as extended care team members, call nurses, receptionists, and administrative personnel—play critical roles as team members, in most clinics they do not share team areas with the core team members. They use separate areas such as the front desk, an administrative office, consultation rooms, or call rooms as their main work areas.
5. Communication between specific roles might occur more often if those individuals must talk to each other due to the nature of their tasks. For instance, providers and rooming nurses are required



## VISIBILITY AND COMMUNICATION

24

to talk to each other to debrief, and staff members sharing their workload (such as RNs or rooming nurses) may need to talk to each other to share status updates.

6. Almost not visible (level 1): Staff members' workstations were in separated workstation clusters, and they were not visible to each other without walking or turning around.

7. Partially visible (level 2): Staff members' workstations were in separated workstation clusters, and they could see some other workstations at their workstations, including when they stood up or moved within their cluster.

8. See each other (level 3): Staff members' workstations were clustered together, with staff with specific roles sitting near each other with direct visual connections. Not necessarily all staff members of one role were located all together; they may have been separated into multiple clusters of workstations.

9. Clinic D provided level 2 visibility between providers and RNs but level 1 visibility between rooming nurses and other roles due to the locations of LPN stations. In Clinic B, a provider area and a rooming nurse area were physically located next to each other but visually disconnected by walls or partitions (level 1). The separated team areas in Clinic A provided partial visibility between staff members with different roles (with the exception of the provider–RN combination).

10. Unreliable responses that did not answer most of the questions and answered with the same point on the scale regardless of the questions were excluded from further analyses.

11. Intra-role communications such as provider–provider (17.6%) or rooming nurse–rooming nurse (22.7%) occurred slightly more frequently compared to inter-role communications such as provider–rooming nurse (10.3%), but the differences were not statistically significant.

12. No instances of visibility level 3 are included since all workstation clusters were adjacent to each other for that visibility level.

## References

- Allen, T. J. (1970). Communication networks in R & D laboratories. *R&D Management, 1*(1), 14–21. doi:10.1111/j.1467-9310.1970.tb01193.x
- Allen, T. J. (2007). Architecture and communication among product development engineers. *California Management Review, 49*(2), 23–41. doi:10.2307/41166381
- Alonso, A., Baker, D. P., Holtzman, A., Day, R., King, H., Toomey, L., & Salas, E. (2006). Reducing medical error in the Military Health System: How can team training help? *Human Resource Management Review, 16*(3), 396–415. doi:10.1016/j.hrmr.2006.05.006
- Archea, J. C. (1984). *Visual access and exposure: An architectural basis for interpersonal behavior* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses database. (Order No. 8506586).
- Barach, P., & Weinger, M. (2007). Trauma team performance. In W. C. Wilson, C. M. Grande, & D. B. Hoyt (Eds.), *Trauma. Vol I. Resuscitation, Anesthesia and Emergency Surgery* (pp. 101–13). New York: Taylor & Francis.
- Bolstad, C. A., Cuevas, H., Gonzalez, C., & Schneider, M. (2005). *Modeling shared situation awareness*. Paper presented at the Proceedings of the 14th Conference on Behavior Representation in Modeling and Simulation (BRIMS), Los Angeles, CA.
- Boutellier, R., Ullman, F., Schreiber, J., & Naef, R. (2008). Impact of office layout on communication in a science-driven business. *R&D Management, 38*(4), 372–391. doi:10.1111/j.1467-9310.2008.00524.x
- Brown, J. B., Lewis, L., Ellis, K., Stewart, M., Freeman, T. R., & Kasperski, M. J. (2009). Mechanisms for communicating within primary health care teams. *Canadian Family Physician, 55*(12), 1216–1222.
- Cai, H., & Zimring, C. (2012). Out of sight, out of reach: Correlating spatial metrics of nurse station typology with nurses' communication and co-awareness in an intensive care unit. In M. Greene, J. Reyes, & A. Castro (Eds.), *Proceedings of the 8th International Space Syntax Symposium* (pp. 8039:1–8039:16). Santiago de Chile: Pontificia Universidad Católica de Chile.
- Carson-Stevens, A., Hibbert, P., Williams, H., Evans, H. P., Cooper, A., Rees, P., . . . , & Edwards, A. (2016). Characterising the nature of primary care patient safety incident reports in the England and Wales National Reporting and Learning System: a mixed-methods agenda-setting study for general practice. *Health Services and Delivery Research, 4*(27), 1-76. doi:10.3310/hsdr04270

## VISIBILITY AND COMMUNICATION

26

- 1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60
- Coiera, E. (2000). When conversation is better than computation. *Journal of the American Medical Informatics Association*, 7(3), 277–286. doi:10.1136/jamia.2000.0070277
- Delva, D., Jamieson, M., & Lemieux, M. (2008). Team effectiveness in academic primary health care teams. *Journal of Interprofessional Care*, 22(6), 598–611. doi:10.1080/13561820802201819
- DuBose, J., Lim, L., & Savitsky, M. (2016, November). *Making sense of behavior mapping in facility planning and design*. Paper presented at the Healthcare Design Conference, Houston, TX.
- Dunn, O. J. (1964). Multiple comparisons using rank sums. *Technometrics*, 6(3), 241–252. doi:10.1080/00401706.1964.10490181
- Elder, N. C., & Dovey, S. M. (2002). Classification of medical errors and preventable adverse events in primary care: A synthesis of the literature. *Journal of Family Practice*, 51(11), 927–932.
- Ellingson, L. L. (2002). Communication, collaboration, and teamwork among health care professionals. *Communication research trends*, 21(3), 3–21.
- Freihoefer, K., Kaiser, L., Vonasek, D., & Bayramzadeh, S. (2017). Setting the stage: A comparative analysis of an onstage/offstage and a linear clinic modules. *Health Environments Research & Design Journal*, 11(2), 89–103. doi:10.1177/1937586717729348
- Gharaveis, A., Hamilton, D. K., & Pati, D. (2017). The impact of environmental design on teamwork and communication in healthcare facilities: A systematic literature review. *Health Environments Research & Design*, 11(1), 119–137. doi:10.1177/1937586717730333
- Gharaveis, A., Hamilton, D. K., Pati, D., & Shepley, M. (2017). The impact of visibility on teamwork, collaborative communication, and security in emergency departments: An exploratory study. *Health Environments Research & Design*, 1–13. doi:10.1177/1937586717735290
- Gum, L. F., Prideaux, D., Sweet, L., & Greenhill, J. (2012). From the nurses' station to the health team hub: How can design promote interprofessional collaboration? *Journal of Interprofessional Care*, 26(1), 21–27. doi:10.3109/13561820.2011.636157
- Gunn, R., Davis, M. M., Hall, J., Heintzman, J., Muench, J., Smeds, B., . . . , & Cohen, D. J. (2015). Designing clinical space for the delivery of integrated behavioral health and primary care. *Journal of the American Board of Family Medicine*, 28 Suppl 1, S52–62. doi:10.3122/jabfm.2015.S1.150053

## VISIBILITY AND COMMUNICATION

27

- Gurascio-Howard, L., & Malloch, K. (2007). Centralized and decentralized nurse station Design: An examination of caregiver communication, work activities, and technology. *Health Environments Research & Design Journal*, 1(1), 44–57. doi:10.1177/193758670700100114
- Hall, E. T. (1966). *The hidden dimension*. New York, NY: Doubleday.
- Heerwagen, J. H., Kampschroer, K., Powell, K. M., & Loftness, V. (2004). Collaborative knowledge work environments. *Building Research & Information*, 32(6), 510–528. doi:10.1080/09613210412331313025
- Herman Miller. (2014). What it takes to collaborate. *Insight*, 1–6. Retrieved from [https://www.hermanmiller.com/content/dam/hermanmiller/documents/research\\_topics/What\\_It\\_Takes\\_to\\_Collaborate.pdf](https://www.hermanmiller.com/content/dam/hermanmiller/documents/research_topics/What_It_Takes_to_Collaborate.pdf)
- Hua, Y., Becker, F., Wurmser, T., Bliss-Holtz, J., & Hedges, C. (2012). Effects of nursing unit spatial layout on nursing team communication patterns, quality of care, and patient safety. *Health Environments Research & Design Journal*, 6(1), 8–38. doi:10.1177/193758671200600102
- IBM. (n.d.). SPSS Statistics 22.0.0. Retrieved from [https://www.ibm.com/support/knowledgecenter/en/SSLVMB\\_22.0.0/com.ibm.spss.statistics\\_22.kc.doc/pv\\_welcome.html](https://www.ibm.com/support/knowledgecenter/en/SSLVMB_22.0.0/com.ibm.spss.statistics_22.kc.doc/pv_welcome.html)
- Jesmin, S., Thind, A., & Sarma, S. (2012). Does team-based primary health care improve patients' perception of outcomes? Evidence from the 2007–08 Canadian Survey of Experiences with Primary Health. *Health Policy*, 105(1), 71–83. doi:10.1016/j.healthpol.2012.01.008
- Karp, Z., Kamnetz, S., Wietfeldt, N., Sinsky, C., Molfenter, T., & Pandhi, N. (2019). Influence of environmental design on team interactions across three family medicine clinics: Perceptions of communication, efficiency, and privacy. *Health Environments Research & Design Journal*, 12(4), 159–173. doi: 10.1177/1937586719834729
- Kennedy, D. M., & Nordrum, J. T. (2015). The Mayo Model of Community Care: Integrating population health and patient experience initiatives for efficient reform. *Journal of Healthcare Management*, 60(2), 91.
- Kilner, E., & Sheppard, L. A. (2010). The role of teamwork and communication in the emergency department: A systematic review. *International Emergency Nursing*, 18(3), 127–137. doi:10.1016/j.ienj.2009.05.006
- Kraut, R., Egidio, C., & Galegher, J. (1988). *Patterns of contact and communication in scientific research collaboration*. Paper presented at the Proceedings of the 1988 ACM Conference on Computer-Supported Cooperative Work, Portland, Oregon.

## VISIBILITY AND COMMUNICATION

28

- Larry, A. M., David, M. L., Suzan, D. O., Susan, M. U., & Frank, J. S. (2003). Culture, the built environment and healthcare organizational performance. *Managing Service Quality*, 13(1), 27–38. doi:10.1108/09604520310456690
- Lim, L., Kanfer, R., Stroebel, R. J., & Zimring, C. M. (2019a). Backstage staff communication: The effects of different levels of visual exposure to patients. *Health Environments Research & Design Journal*, Advance online publication. doi:10.1177/1937586719888903
- Lim, L., Kanfer, R., Stroebel, R. J., & Zimring, C. M. (2019b). Visibility and teamwork perception: Differential effects of visual access of team area on staff and patient teamwork perception. Manuscript submitted for publication.
- Lim, L., Kim, M., & Zimring, C. M. (2019). Measuring Interpersonal Visual Relationships in Healthcare Facilities: The Agent Visibility Model and SAVisualPower Tool. *Health Environments Research & Design Journal*, 12(4), 203–216. doi:10.1177/1937586719842357
- Lu, Y., & Seo, H.-B. (2012). The effect of hospital unit layout on nurse walking behavior. *Health Environments Research & Design Journal*, 6(1), 66–82. doi:10.1177/193758671200600104
- Lu, Y., & Zimring, C. (2012). Can intensive care staff see their patients? An improved visibility analysis methodology. *Environment and Behavior*, 44(6), 861–876. doi:10.1177/0013916511405314
- Luff, P., Heath, C., & Greatbatch, D. (1992). *Tasks-in-interaction: Paper- and screen-based documentation in collaborative activity*. Paper presented at the Proceedings of the 1992 ACM Conference on Computer-Supported Cooperative Work, Toronto, Ontario, Canada.
- Markhede, H., & Koch, D. (2007, June 12–15). *Positioning analysis: Social structures in configurative modelling*. Paper presented at the 6th International Space Syntax Symposium, Istanbul, Turkey.
- McDonald, L. R., Luke, J., Jude, V., Madden, R., & Chan, K. (2012). Medication Errors Among Pediatric Hematopoietic Stem Cell Transplant Recipients in an Outpatient Clinic. *Biology of Blood and Marrow Transplantation*, 18(2), S280. doi:10.1016/j.bbmt.2011.12.210
- National Committee for Quality Assurance. (n.d.). Patient-Centered Medical Home (PCMH) recognition. Retrieved from <http://www.ncqa.org/programs/recognition/practices/patient-centered-medical-home-pcmh>
- Pati, D., Harvey, T. E., Redden, P., Summers, B., & Pati, S. (2015). An empirical examination of the impacts of decentralized nursing unit design. *Health Environments Research & Design Journal*, 8(2), 56–70. doi:10.1177/1937586715568986

## VISIBILITY AND COMMUNICATION

29

- Peavey, E., & Cai, H. (2018). A systems framework for understanding the environment's relation to clinical teamwork: A systematic literature review of empirical studies. *Environment and Behavior*. Advance online publication. doi:10.1177/0013916518815535
- Penn, A., Desyllas, J., & Vaughan, L. (1999). The space of innovation: Interaction and communication in the work environment. *Environment and Planning B: Planning and Design*, 26(2), 193–218. doi:10.1068/b4225
- Penn, A., & Hillier, B. (1992, June 30–July 3). The social potential of buildings: Spatial structure and the innovative milieu in scientific research laboratories. In *Corporate Space and Architecture. International Symposium* (pp. 39–43). Ministère de l'Équipement du Logement et des Transports, Paris, France.
- Peponis, J., Bafna, S., Bajaj, R., Bromberg, J., Congdon, C., Rashid, M., . . . , & Zimring, C. (2007). Designing space to support knowledge work. *Environment and Behavior*, 39(6), 815–840. doi:10.1177/0013916506297216
- Prgomet, M., Georgiou, A., & Westbrook, J. I. (2009). The impact of mobile handheld technology on hospital physicians' work practices and patient care: a systematic review. *Journal of the American Medical Informatics Association*, 16(6), 792–801. doi:10.1197/jamia.M3215
- Pullon, S., Morgan, S., Macdonald, L., McKinlay, E., & Gray, B. (2016). Observation of interprofessional collaboration in primary care practice: A multiple case study. *Journal of Interprofessional Care*, 30(6), 787–794. doi:10.1080/13561820.2016.1220929
- Rashid, M., Boyle, D., & Crosser, M. (2014). Network of spaces and interaction-related behaviors in adult intensive care units. *Behavioral Sciences*, 4(4), 487. doi:10.3390/bs4040487
- Rashid, M., Kampschroer, K., & Zimring, C. (2006). Spatial layout and face-to-face interaction in offices—A study of the mechanisms of spatial effects on face-to-face interaction. *Environment and Planning B: Planning and Design*, 33(6), 825–844. doi:10.1068/b31123
- Rashid, M., Wineman, J., & Zimring, C. (2009). Space, behavior, and environmental perception in open-plan offices: A prospective study. *Environment and Planning B: Planning and Design*, 36(3), 432–449. doi:10.1068/b33034
- Real, K., Bardach, S. H., & Bardach, D. R. (2017). The role of the built environment: How decentralized nurse stations shape communication, patient care processes, and patient outcomes. *Health Communication*, 32(12), 1557–1570. doi:10.1080/10410236.2016.1239302



## VISIBILITY AND COMMUNICATION

30

- Reddy, M. C., & Spence, P. R. (2008). Collaborative information seeking: A field study of a multidisciplinary patient care team. *Information Processing & Management*, *44*(1), 242–255. doi:<https://doi.org/10.1016/j.ipm.2006.12.003>
- Sailer, K., Budgen, A., Lonsdale, N., Turner, A., & Penn, A. (2007). *Effective workplaces—Bridging the gap between architectural research and design practice*. Paper presented at the 6th International Space Syntax Symposium, Istanbul, Turkey.
- Sailer, K., Budgen, A., Lonsdale, N., Turner, A., & Penn, A. (2009). *Comparative studies of offices pre and post—How changing spatial configurations affect organisational behaviours*. Paper presented at the Proceedings of the 7th International Space Syntax Symposium, Stockholm, Sweden.
- Schottenfeld, L., Petersen, D., Peikes, D., Ricciardi, R., Burak, H., McNellis, R., & Genevro, J. (2016). *Creating patient-centered team-based primary care*. Agency for Healthcare Research and Quality, U.S. Department of Health and Human Services. AHRQ Publication No. 16-0002-EF
- Shoemaker, S. J., Parchman, M. L., Fuda, K. K., Schaefer, J., Levin, J., Hunt, M., & Ricciardi, R. (2016). A review of instruments to measure interprofessional team-based primary care. *Journal of Interprofessional Care*, *30*(4), 423–432. doi:[10.3109/13561820.2016.1154023](https://doi.org/10.3109/13561820.2016.1154023)
- Shortell, S. M., Rousseau, D. M., Gillies, R. R., Devers, K. J., & Simons, T. L. (1991). Organizational assessment in intensive care units (ICUs): Construct development, reliability, and validity of the ICU nurse-physician questionnaire. *Medical Care*, *29*(8), 709–726.
- Stroebel, R. J., Obeidat, B., Lim, L., Mitchell, J. D., Jaspersen, D. B., & Zimring, C. (2019). The impact of clinic design on teamwork development in primary care. *Health Care Management Review*. Published ahead of print. doi:[10.1097/hmr.0000000000000259](https://doi.org/10.1097/hmr.0000000000000259)
- Sweeney, M., Paruchuri, K., & Weingart, S. N. (2018). Going mobile: Resident physicians' assessment of the impact of tablet computers on clinical tasks, job satisfaction, and quality of care. *Applied Clinical Informatics*, *09*(03), 588–594. doi:[10.1055/s-0038-1667121](https://doi.org/10.1055/s-0038-1667121)
- Turner, A., Doxa, M., O'Sullivan, D., & Penn, A. (2001). From Isovists to visibility graphs: A methodology for the analysis of architectural space. *Environment and Planning B: Planning and Design*, *28*(1), 103–121. doi:[10.1068/b2684](https://doi.org/10.1068/b2684)
- U.S. Department of Veterans Affairs. (n.d.). Patient Aligned Care Team. Retrieved from <https://www.patientcare.va.gov/primarycare/PACT.asp>
- Wauben, L. S. G. L., Dekker-van Doorn, C. M., van Wijngaarden, J. D. H., Goossens, R. H. M., Huijsman, R., Klein, J., & Lange, J. F. (2011). Discrepant perceptions of communication,

## VISIBILITY AND COMMUNICATION

31

teamwork and situation awareness among surgical team members. *International Journal for Quality in Health Care*, 23(2), 159–166. doi:10.1093/intqhc/mzq079

Webster, J. S., King, H. B., Toomey, L. M., Salisbury, M. L., Powell, S. M., Craft, B., . . . Salas, E. (2008). Understanding quality and safety problems in the ambulatory environment: Seeking improvement with promising teamwork tools and strategies. In K. Henriksen, J. B. Battles, M. A. Keyes, & M. L. Grady (Eds.), *Advances in Patient Safety: New Directions and Alternative Approaches (Vol. 3: Performance and Tools)*. Rockville (MD): Agency for Healthcare Research and Quality (US).

Wineman, J., & Adhya, A. (2007). *Enhancing workspace performance: Predicting the influence of spatial and psychosocial factors on job satisfaction*. Paper presented at the Proceedings of the 6th International Space Syntax Symposium, Istanbul, Turkey.

Wineman, J., & Serrato, M. (1997). *Enhancing communication in lab-based organisations*. Paper presented at the 1st International Space Syntax Symposium, London, United Kingdom.

Zborowsky, T., Bunker-Hellmich, L., Morelli, A., & O'Neill, M. (2010). Centralized vs. decentralized nursing stations: Effects on nurses' functional use of space and work environment. *Health Environments Research & Design Journal*, 3(4), 19–42. doi:10.1177/193758671000300404



## VISIBILITY AND COMMUNICATION

32

Table 1.

*Summary Descriptions of the Selected Primary Care Clinics*

Characteristics	Clinic A	Clinic B	Clinic C	Clinic D
Organization	X	X	Y	Y
Geographic location	Georgia	Georgia	Wisconsin	Minnesota
Year built/renovated	2011	2012	2016	2016
Clinic area (centerline, square feet)	2,859	12,179	12,251	21,684
Enrolled patient population	4,000	11,400	4,000	15,000
Number of non-admin staff	14	34	27	60
Number of teams	1	2	1	2
Number of team areas	3	6	1	1
Workstations clustered by	Same roles	Same roles	Different roles	Same roles

## VISIBILITY AND COMMUNICATION

33

Table 2.

*Summary Results of the Staff Visibility Variables*

Variables	Clinic A	Clinic B	Clinic C	Clinic D
<b>Clinic Level: Visual Connections of Staff Workstations</b>				
Number of workstations	14	33	21	53
Average number of visible other workstations	4.4	7.0	5.7	27.5
Total number of other workstations	13	32	20	52
Ratio	34.1%	22.0%	28.6%	53.0%
<b>Space Level: Visual Connections between Staff Workstations and Clinic Spaces <sup>a</sup></b>				
Number of workstations	14	33	21	53
Average number of visible space points	363.9	382.2	625.6	1,722.8
Total number of space points	1,197	4,591	2,186	7,305
Ratio (average visible points/total points)	30.4%	8.3%	28.6%	23.6%
<b>Workstation Level: Visual Connections of Staff Workstation Clusters, Role-Specific (Level 1 = Almost not visible, level 2 = Partially visible, level 3 = See each other) <sup>b</sup></b>				
Provider–Provider	3	3	2	3
RN–RN	3	3	2	3
ROOM–ROOM	3	3	2	3
Provider–RN	1	1	3	2
RN–ROOM	2	1	3	1
ROOM–Provider	2	1	3	1

<sup>a</sup> While the visibility levels are compared in space levels, the results of the variable are aggregated in the clinic level in this table.

<sup>b</sup> Almost not visible (level 1): Staff members' workstations were in separated workstation clusters, and they were almost not visible to each other without walking or turning around; Partially visible (level 2): Staff members' workstations were in separated workstation clusters, and they could see some other workstations at their workstations, including when they stood up or moved within their cluster; See each other (level 3): Staff members' workstations were clustered together, with staff with specific roles sitting near each other with direct visual connections. Not necessarily all staff members of one role were located all together; they may have been separated into multiple clusters of workstations.

## VISIBILITY AND COMMUNICATION

34

Table 3.

*Demographic and Summary Results of Communication Measurements*

Measurements	Clinic A	Clinic B	Clinic C	Clinic D
Staff Survey				
Participants	14	15	19	35
Roles <sup>a</sup>	4 PR 3 ROOM 1 RN 2 CALL 2 EX 1 FD 1 AD	5 PR 7 ROOM 3 FD	2 PR 5 ROOM 3 RN 4 EX 4 FD 1 AD	8 PR 9 ROOM 8 RN 3 CALL 1 EX 3 FD 3 AD
Available staff members during the visits	16	26	24	63
Response rate	88%	58%	79%	56%
Communication frequency (1 item) Mean	4.43	4.07	4.53	4.89
Communication frequency (1 item) SD	0.51	0.70	0.51	0.32
Timely communication (4 items) Mean	3.96	3.53	3.86	4.03
Timely communication (4 items) SD	0.80	0.35	0.67	0.51
Behavior Mapping Observations				
Total observation rounds	78	54	37	24
Intervals between rounds (minutes)	10	15	15	30
Total recorded individuals	850	661	667	1,346
Total recorded interacting individuals	341	236	323	436
Average number of recorded individuals per round	10.9	12.2	18.0	56.1
Average number of recorded interacting individuals per round	4.4	4.4	8.7	18.2
Observed interacting staff members/observed staff members	40%	32%	46%	31%
Observed interacting core staff members/observed core staff members	14%	12%	14%	16%

<sup>a</sup> PR = primary care providers (e.g., physicians, nurse practitioners, physician assistants), ROOM = rooming nurses (e.g., medical assistants, licensed practical nurses), RN = registered nurses, CALL = call nurses other than RNs (e.g., licensed practical nurses, patient appointment coordinators), EX = extended care members (e.g., nutritionists, behavior health providers, pharmacists, care coordinators), FD = front desk receptionists, AD = administrative personnel.

## VISIBILITY AND COMMUNICATION

35

Table 4.

*Descriptive Results of the Observed Communication Frequencies between Specific Staff Roles*

Interactions by Role	Clinic A	Clinic B	Clinic C	Clinic D
<b>Provider–Provider (PR–PR)</b>				
Observed number of providers	174	154	54	224
Observed number of provider-provider interactions	69	16	2	38
Observed interactions/observed individuals (%)	39.7%	10.4%	3.7%	17.0%
<b>RN–RN</b>				
Observed number of RNs	142	76	47	177
Observed number of RN-RN interactions	10	28	8	41
Observed interactions/observed individuals (%)	7.0%	36.8%	17.0%	23.2%
<b>Rooming nurse–Rooming nurse (ROOM–ROOM)</b>				
Observed number of rooming nurses	170	289	88	239
Observed number of ROOM–ROOM interactions	32	43	12	104
Observed interactions/observed individuals (%)	18.8%	14.9%	13.6%	43.5%
<b>Provider–RN</b>				
Observed number of providers and RNs	316	230	101	401
Observed number of provider–RN interactions	6	0	15	13
Observed interactions/observed individuals (%)	1.9%	0.0%	14.9%	3.2%
<b>RN–Rooming nurse (RN–ROOM)</b>				
Observed number of RNs and rooming nurses	312	365	135	416
Observed number of RN–ROOM interactions	13	14	20	7
Observed interactions/observed individuals (%)	4.2%	3.8%	14.8%	1.7%
<b>Rooming nurse–Provider</b>				
Observed number of providers and rooming nurses	344	443	142	463
Observed number of ROOM–Provider interactions	35	22	31	20
Observed interactions/observed individuals (%)	10.2%	5.0%	21.8%	4.3%

*Note.* Only providers, RNs, and rooming nurses are considered, generating six different combinations of communication counterparts.

## VISIBILITY AND COMMUNICATION

36

Table 5.

*Observed Communication and Staff Postures*

Observed Communication Instances Per Posture	Clinic A	Clinic B	Clinic C	Clinic D
Total number of observed staff communication instances	130	82	79	125
Communication instances of all standing or walking staff members	11	18	19	21
Communication instances involving a mixture of sitting and standing or walking staff members	49	28	36	49
Communication instances of all sitting staff members	70	36	24	55
Sitting-included ratio (at least one sitting staff communication instance/all observed communication instances)	92%	78%	76%	83%

## VISIBILITY AND COMMUNICATION

37

Table 6.

*Observed Communication and Engaged Devices*

Observations	Clinic A	Clinic B	Clinic C	Clinic D
Total number of observed staff communication instances	130	82	79	125
No-computer-involved communication instances	81	51	58	81
Computer-involved communication instances	49	31	21	44
Clinic staff use laptop (Y/N)	Yes (PR)	No	No	No
Computer-involved ratio (computer-involved communication instances/all observed communication instances)	38%	38%	27%	35%

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

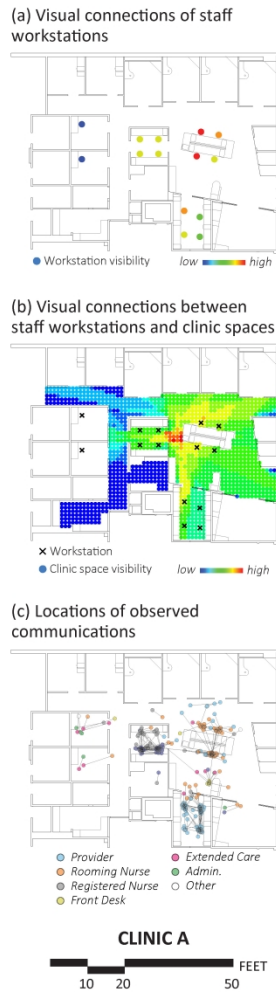
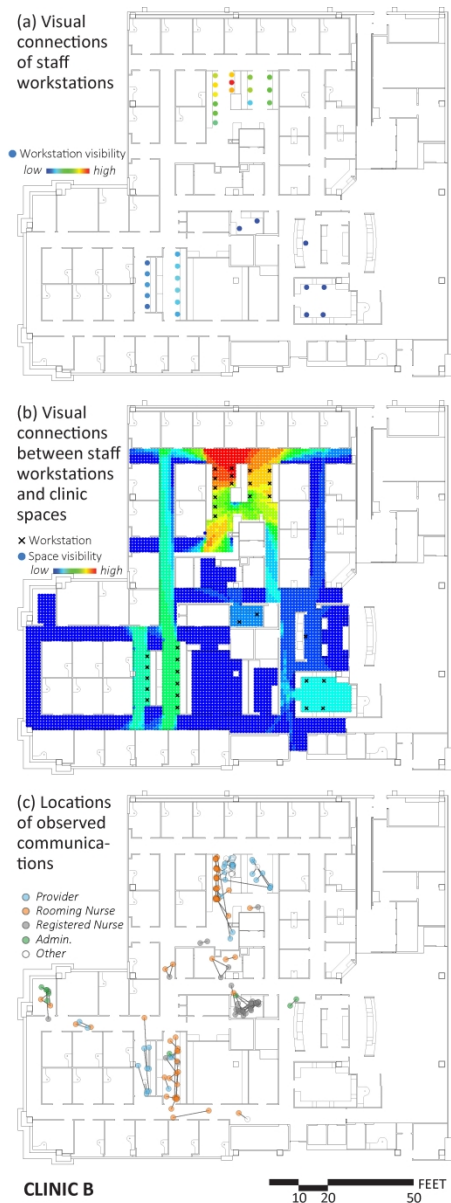


Figure 1. [In color online.] Visibility levels and communication locations in Clinic A. These results represent the two visibility variables, (a) visual connections of staff workstations and (b) visual connections between staff workstations and clinic spaces, in a color scheme. Also, the bottom figure illustrates (c) locations of all observed communication between staff members. Each circle indicates an individual, and lines represent observed communication instance(s) among the connected circles.

190x228mm (600 x 600 DPI)



45 Figure 2. [In color online.] Visibility levels and communication locations in Clinic B. These results represent  
46 the two visibility variables, (a) visual connections of staff workstations and (b) visual connections between  
47 staff workstations and clinic spaces, in a color scheme. Also, the bottom figure illustrates (c) locations of all  
48 observed communication between staff members. Each circle indicates an individual, and lines represent  
49 observed communication instances among the connected circles.

50 190x228mm (600 x 600 DPI)



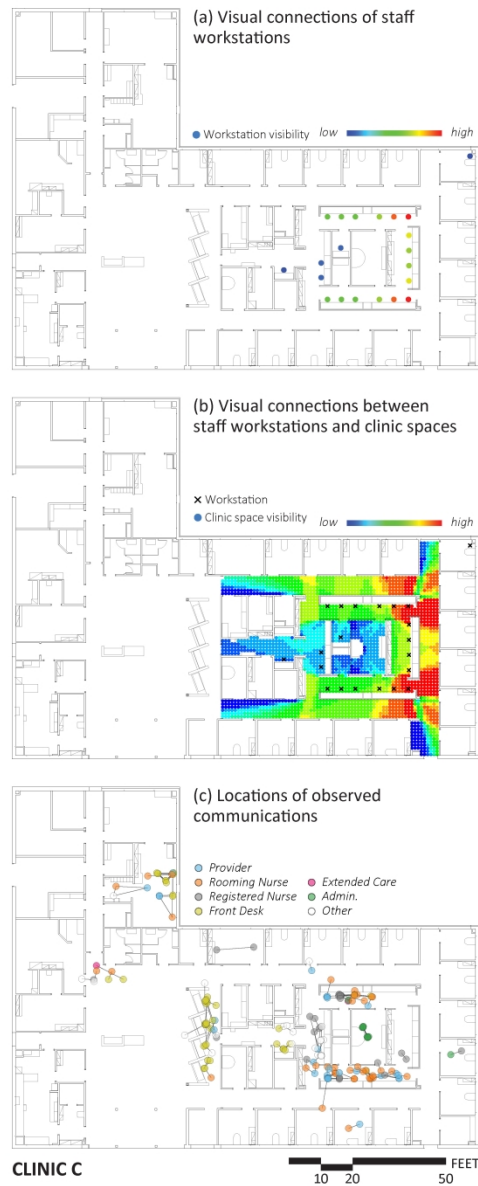
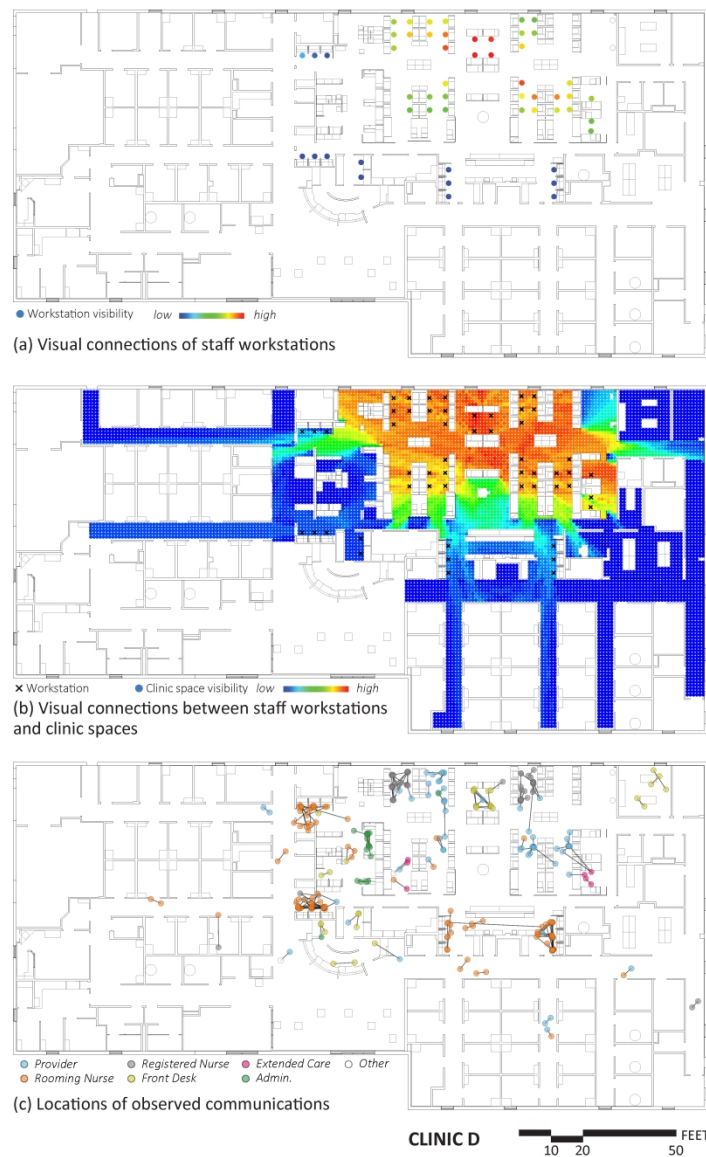


Figure 3. [In color online.] Visibility levels and communication locations in Clinic C. These results represent the two visibility variables, (a) visual connections of staff workstations and (b) visual connections between staff workstations and clinic spaces, in a color scheme. Also, the bottom figure illustrates (c) locations of all observed communication between staff members. Each circle indicates an individual, and line(s) represent observed communication instances among the connected circles.

190x228mm (600 x 600 DPI)



45 Figure 4. [In color online.] Visibility levels and communication locations in Clinic D. These results represent  
46 the two visibility variables, (a) visual connections of staff workstations and (b) visual connections between  
47 staff workstations and clinic spaces, in a color scheme. Also, the bottom figure illustrates (c) locations of all  
48 observed communications between staff members. Each circle indicates an individual, and line(s) represent  
49 observed communication instance(s) among the connected circles.

50 190x228mm (600 x 600 DPI)

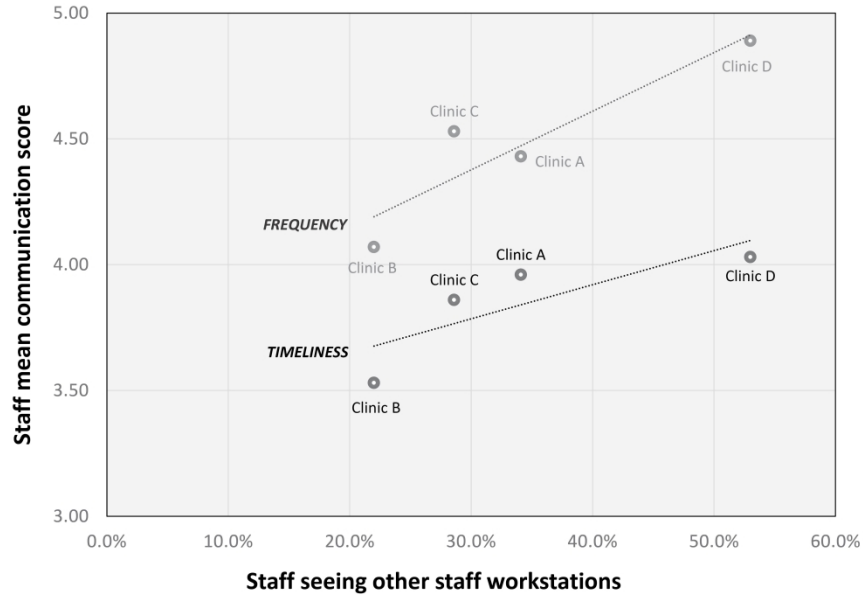


Figure 5. Staff seeing other staff workstations and two communication perception constructs. Staff at clinics with higher levels of staff seeing other staff workstations reported that they had more timely and frequent communication.

254x190mm (600 x 600 DPI)

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

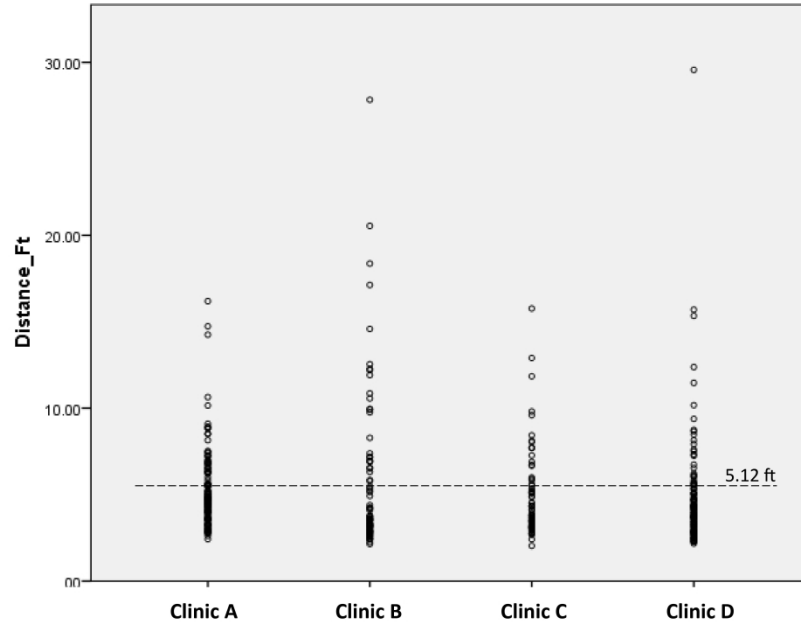


Figure 6. Scatter plot of communication distances (feet) in each clinic. Staff members talked to each other at a close distance (on average 5.12 feet across clinics).

254x190mm (600 x 600 DPI)

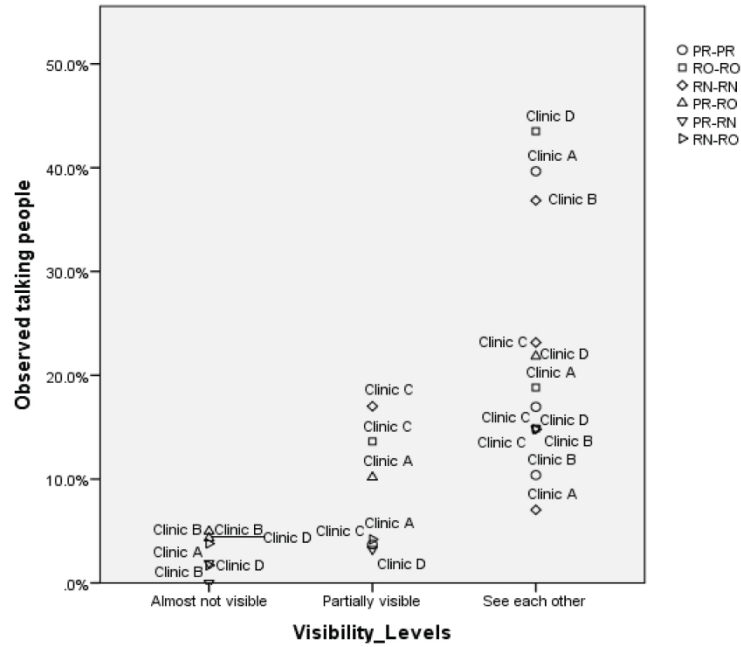


Figure 7. Observed frequency of communication in relation to clinics, communication counterparts, and categorical visibility levels. More communication occurred between workstation clusters with more visual connections regardless of staff roles. (PR: providers, RO: rooming nurses).

254x190mm (600 x 600 DPI)