

Effects of Emergency Department Physical Design Elements on Security, Wayfinding, Visibility, Privacy, and Efficiency and Its Implications on Staff Satisfaction and Performance

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Abstract

Objective: The purpose of this study was to identify the role of emergency department (ED) design on ED staff satisfaction and performance. **Background:** High patient volume, surging workloads, and violent behaviors are expected pressures for ED staff. Literature suggests the substantial role of the physical environment in the delivery of care and its role in staff and patient experiences. Nevertheless, limited studies have explored simultaneous interactions between ED physical design elements, attributes (security, wayfinding, visibility, privacy, and efficiency), and staff satisfaction or performance. **Method:** Interviews, surveys, visibility graph analysis, and agent simulations were employed to understand the connection between ED physical design, attributes, performance, and staff satisfaction. **Results:** Enhanced security, effective wayfinding, team visibility, noise reduction, adequate privacy, and accessible supplies and equipment were significant predictors of staff satisfaction and performance. Unobstructed views in waiting and triage and controlled entrances were critical for improving security. To improve wayfinding, eye-level signage, reducing surveillance obstacles, and creating direct public routes were recommended. Rectangular units with multiple perpendicularly connected corridors and linear pod arrangements enhanced movement. Including team rooms and enclosed ERs were recommended for privacy improvements. Visibility was critical for team communication and improved by including short-distanced perpendicular corridors and eliminating columns. Enhancing access to supplies or equipment and reducing noise levels improved the perception of staff efficiency. **Conclusion:** The findings contribute to the general body of knowledge on the impact of ED physical design on attributes that potentially improve staff satisfaction and work performance.

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For Peer Review

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Abstract

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3 The stressful and challenging work environment in emergency departments (EDs) is well
4 recognized. The delivery of care is impacted by the construction of the surrounding environment.
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6 Despite the fundamental role of environmental qualities affecting staff satisfaction and
7
8 performances, more recognition is needed for the pivotal role of the physical environment in
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10 EDs. Among the necessary suggested ED qualities, this paper focuses on the following
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12 subtopics: (a) security; (b) wayfinding; (c) visibility; (d) privacy; and (e) efficiency.
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17 Violence and aggressive behavior in the ED is prevalent and is linked to compromising
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19 staff job performance, productivity, depression, attention, and morale (Gates et al., 2011; Pati,
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21 Pati, & Harvey, 2016; Pich, Hazelton, Sundin, & Kable, 2010). Additionally, enhancing the
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23 feeling of safety in EDs leads to job satisfaction and less turnover (Gates et al., 2011). Many
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25 studies propose process and management interventions for enhancing security issues in EDs
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27 (Pich et al., 2010) . Nevertheless, there has been little attention given to the role of the ED
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29 physical environment in security outcomes.
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33 Studies have found that wayfinding in healthcare environments impacts nurses'
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35 behaviors, comfort, stress, and performances (Mustikawati, Yatmo, & Atmodiwirjo, 2017; Pati,
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37 Harvey, Willis, & Pati, 2015). Yet, wayfinding studies that focus on ED layout configuration and
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39 spatial cues are rarely conducted. This comprehension is critical and current as hospital-based
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41 EDs are tackling wayfinding challenges for their complex appearance and growing connections
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43 to other departments.
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47 Visibility is another substantial quality for the ED delivery of care. Higher visibility
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49 enhances staff awareness of patient conditions and prevents unsafe behaviors (Pati, Harvey, &
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51 Pati, 2014; Pati et al., 2016). Additionally, visibility impacts the quality of team work between
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53 clinical staff by supporting routine face-to-face communication (Gharaveis, Hamilton, Pati, &
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Shepley, 2017; Pati et al., 2014). Nevertheless, there is a lack of comprehensive understanding of the impacts of design consideration and improvement on visual connections in EDs and its relationship with staff performance and satisfaction.

Privacy in healthcare environments is an ethical concern and critical for patients' physical and mental wellbeing (Lin et al., 2013; Pines & McCarthy, 2011). The ED department is unique as patients are usually in overcrowded conditions that infringe privacy and confidentiality (Calleja & Forrest, 2011; Lin et al., 2013; Pines & McCarthy, 2011). More research is needed to evaluate how the spatial layout and attribute of EDs can protect patient privacy and if safeguarding patient or team privacy improves for staff performance or satisfaction.

The scarce body of literature focusing on the impact of physical design on efficiency outcomes suggest that exam room (ER) standardization, providing adequate space, and noise levels bear implications on efficiency outcomes (Adkins, Foran, Gill, Delatore, & Moseley, 2017; Fay, Carll-White, & Real, 2018; Pati et al., 2014). Further, effective teamwork, visibility, and accessibility that are affected by the built environment bear positive implications for efficiency outcomes (Fay et al., 2018; Gharaveis et al., 2017; Pati et al., 2014). Whereas the limited previous research in the context of ED settings have separately explored security, wayfinding, visibility, privacy, and efficiency qualities, more research is needed on how these qualities interact with each other to support staff performance and satisfaction. Implications of this knowledge on ED buildings can contribute to a more pleasant and supportive workplace for ED staff.

Objective

The aim of this study was to study the relationship between ED spatial attributes linked to physical environment properties and its effects on staff satisfaction and performances. The

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3 research explored the following questions: (a) how does the ED physical quality facilitate or
4 impede perceptions of security, wayfinding, visibility, privacy, and efficiency; and (b) what is
5 the nature of the relationship between perceptions of ED security, wayfinding, visibility, privacy,
6 and efficiency on staff performance or satisfaction. By exploring the interaction of physical
7 design elements and different parameters on staff performance and satisfaction, this study
8 focuses on refining solutions from a physical design standpoint.
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Method

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21 Structured interviews and surveys of frontline staff were collected from two EDs, one
22 featured *centralized nursing units* (Figure 1), and the other incorporated *decentralized nursing*
23 *units* (Figure 2).
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28 "[Place Figure 1 and 2 approximately here]"
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30 Departmental email notifications were sent to recruit staff for interviews and surveys.
31 Structured interviews explored significant barriers and bottlenecks, ways to improve, and
32 necessary modifications from physicians, shift managers, and nurses ($n = 8$). Interviews were
33 recorded, transcribed, and clustered into themes. To ensure the validity of themes, peer
34 debriefing and external reviews were applied.
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41 The surveys were designed to collect data on perceptions of spaces, delivery of care,
42 services and operations, bottlenecks, visibility, communication and collaboration, satisfaction,
43 and recommended improvements. Survey questions included items scored on a five-point rating
44 scale and were collected from 67 staff in both sites. Simple linear regression was used to
45 determine the magnitude of the relationship between physical, staff performance, or satisfaction.
46 Further, stepwise regression models were generated for understanding significant predictors of
47 ease of access to equipment and supplies.
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For analytical evaluation of spatial layouts, the study employed the Depthmap software to perform Visibility Graph Analysis (VGA) and agent-based simulation (Turner & Penn, 2002).

Visual integration HH illustrates how visually connected all spaces are in the footprint and identifies barriers to the visual field (Turner, 2004). The agent-based simulation yields gate count values that represent the number of pedestrian flow per time unit in the environment (Al_Sayed & Turner, 2012). Tests of Normality on the agent analysis dataset indicated significant deviation from a normal distribution ($p = .21$, $df = 45928$, $p < .001$). Therefore, non-parametric Mann-Whitney Tests was employed to evaluate significant difference between gate count mean values in both sites. The data were analyzed using the SPSS software (version 24.0).

Findings

To guide future architectural decisions, this study combined multiple methods that address spatial characteristics in EDs that impact staff satisfaction and work performance. The following section describes responses and spatial analytic outcomes concerning: security, wayfinding, visibility, privacy, and efficiency.

Security

Table 1 illustrates survey responses. The analysis indicated that security and safety upon arrival and when entering were an issue of consideration to respondents ($M = 2.7$, $n = 64$, $SD = 1.05$). Adequate visibility accounted for a 7% variance in the perception of safety, $F(1, 61) = 4.65$, $p = .035$, and 15.6% of variability in staff satisfaction, $F(1, 60) = 11.11$, $p = .001$. Additionally, the perception of safety explained 34% of variability in work satisfaction responses, $F(1, 61) = 18.53$, $p < .001$.

"[Place Table 1 approximately here]"

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Ineffective wayfinding systems around the ED entrances and exit routes raised safety concerns. Staff believed multiple entrances, blind spots, and visitors walking behind the registration desk intruded security. For instance, one nurse indicated, “I wish we had better security as far as getting in and out of the triage doors. It is easy for someone to just enter and walk through our department.” Another respondent mentioned, “Outsiders have too much access to the ED and this is a safety concern.”

ED staff recommended micro modifications such as establishing mirrors, metal detectors, or bullet proof glassed nursing station areas as a means of enhancing security implications. For example, a respondent reflected on the need for protective barriers, “There is no protection for the staff up front if caught off guard. We may need a bullet-proof glass or a more closed-in area, along with all nursing stations.” ED staff believed that providing separated waiting and triage areas for BH patient promotes security. For example, a participant noted:

Homeless and psychiatric patients have nowhere to go. They sit and wait until we can get a social worker down to talk to them. If we had a separate room, like a sub-waiting room with some privacy, their needs could be better addressed.

Wayfinding

The agent analysis investigated how the ED spatial arrangement affected agent movements. Corridors with more obstacles and indirect connections produced more diversity of sightlines, as seen in site 1 (Figure 3). Additionally, movement patterns in the waiting area were obstructed by columns or walls. Conversely, in site 2, the rectangular unit shape with linear pod alignments and perpendicularly connected corridors enhanced movement and visibility (Figure 4). However, the T-shaped unit inhibited movement patterns from pod 1 to other pods. In both sites, there were inadequate density of agent traces in many areas, such as the corridors linking

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the triage to exam rooms or the waiting areas, impacting wayfinding experiences. Average gate count values were higher in site 2 than site 1, $M = 19.28$, $SD = 27.56$, $M = 18.64$, $SD = 22.58$, respectively, and this difference was significant, $U = 254024837.0$, $z = -6.53$, $p < 0.001$.

"[Place Figure 3 and 4 approximately here]"

Exploring the survey responses, wayfinding improvement was cited as significant in reducing the occurrences of bottlenecks, and thus staff performance $F(1, 31) = 5.44$, $p = .026$. However, it was not a significant predictor of staff satisfaction. Confusing and indirect hospital circulation zones between public parking, the ED entrance, and hospital corridors elicited wayfinding issues for visitors. This situation imposed ED staff to personally guide patients to other departments, reducing operational outcomes. Including visual cues and landmarks, such as “colored arrows” to destinations, was recommended.

Visibility

The VGA maps illustrate poor visibility (higher density of blue) around the waiting room areas in both sites (Figure 5 and 6). As illustrated in the diagrams, columns impeded visibility, especially in the registration, waiting, and POD areas. In the central nursing units, support spaces restricted visibility towards patient rooms (site 1). Intersecting corridors at short intervals resulted in higher visibility saturations (red colors) around hallways and nursing stations in site 2, versus site 1.

"[Place Figure 5 and 6 approximately here]"

Sufficient surveillance towards patients and having face-to-face communication with colleagues accounted for 15.6% of variability in staff satisfaction, $F(1, 61) = 11.11$, $p = .001$. Adequate visibility significantly predicted satisfaction with finding team members, $F(1, 62) = 70.12$, $p < .001$; communicating with team members within pods, $F(1, 62) = 38.5$, $p < .001$;

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3 communicating with team members across pods, $F(1, 61) = 36.8, p < .001$; and enhancing
4 overall coordination with team members, $F(1, 61) = 28.6, p < .001$. Sufficient team visibility
5 explained 16.3% of variability in staff satisfaction, $F(1,58) = 11.3, p = .001$. Patient visibility
6 accounted for 7.5% of variability in explaining the staff satisfaction outcome, $F(1, 59) = 4.8, p =$
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13 .033.

14 ED staff believed that decentralized pods increased proximity and access to patient
15 rooms, allowing for more efficient and effective monitoring of patients. However, the enhanced
16 patient proximity was countered by reduced team visibility and social isolation in decentralized
17 pods. For instance, one nurse reported, “the pod setup makes it difficult for providers to
18 communicate with each other and the focus on patients is lost.” The ED manager indicated,
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30 “There is no visual connection between pods. So, communication depends on the nurses. The
31 lack of visibility is problematic for physicians too, as they prefer side-by-side communication.”

31 In centralized pods, staff recommended open, wall-less, column-less central areas that
32 contributed to visual and auditory access for patient monitoring. The lack of visibility between
33 pods was a barrier to communication that required additional tasks, as elaborated by a
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60 respondent, “it is hard to find team members but overall not too bad. To easily communicate with
other pod members, I usually need to walk to the other pod or find a computer to locate their
phone numbers.”

Staff perceived improved levels of non-verbal communication by reducing visual
barriers. One of the nurses elaborated on this issue, “Our pivot nurse cannot see into the waiting
room because there is a column blocking the view.” A physician noted:

The ideal ED to me is something that has no visual barriers, and that back-and
forth non-verbal coordination happens between the physician and the team; so that no

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matter where you are, you can see your patients, techs, and patient nurses, secretary, and nurses.

Privacy

Ease of private interaction with patients accounted for 7.4% of variation in staff satisfaction, $F(1, 60) = 4.8, p = .032$. The ease of private conversations with team members explained 15% of variation in staff satisfaction, $F(1, 60) = 10.6, p = .002$, and 28% of variance in satisfactory communication with team members across pods, $F(1, 61) = 23.21, p < .001$. Satisfaction with pod configurations was affected by staff perception of not having satisfactory private conversations with team members, $F(1, 47) = 5.2, p = .027$.

In the check-in areas separated booths; and in triage and ERs doors were recommended changes to enhance acoustical privacy and protect patient confidentiality, especially during overcrowded periods. Users mentioned the need for sound absorbent materials that support private conversation, as one respondent mentioned:

Having private conversations with patients can be difficult because there are no doors on the patient rooms and some people speak loudly. Having a private report can also be difficult unless we go to the med room with the computer as voices can easily be overheard, and the patients can walk by during report.

The need for spatial arrangements that support team discussions was discussed in some comments, for example, “There is no area of Care Station C that team members are able to have private interactions, whether discussing patient information or personal information.”

Efficiency

Based on survey and interview responses, access to supplies and noise were two substantial environmental factors that correlated with ED efficiency. Ease of access to supplies

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accounted for 12.6% of variation in staff satisfaction, $F(1, 50) = 7.2, p = .01$. Further, ease of communication with team members across pods, $\beta = .38, p = .002$, and feeling part of a team, $\beta = .414, p = .015$, accounted for 38% of the variation in the perception of accessible supplies, $F(2, 41) = 12.53, p < .001$. That is, the more supplies were accessible and equally distributed, the more staff felt part of a team.

The analysis indicated that easily accessible equipment pertained to 13% of variation in staff satisfaction, $F(1, 51) = 7.53, p = .008$. This outcome was positively predicted by ease of communication with team members across pods, $\beta = .58, p < .001$, and shorter door-to-admission or door-to-discharge times, $\beta = .175, F(2, 41) = 31.6, p < .001, R^2 = .61$.

Staff were disturbed by ED noise levels ($M = 2.24, n = 63, SD = .89$). Noisy environments accounted for a 34.2% of variance among those feeling distracted and unfocused, $F(1, 60) = 31.15, p < .001$. However, the perception of a noisy environment was not a significant predictor of staff satisfaction, communication within or across pods, or the need for pod modifications.

Standardization of equipment and supply location were emphasized to eliminate confusion or distraction from tasks, and enhance efficiency. A nurse described the need for standardized supply arrangements, "Supplies in the pods are not all the same, sometimes you have to go from pod to pod and sometimes to the storage room just to find what you need to do your job." Another participant explained the effect of inaccessible supplies on throughput outcomes:

It would be great to have supplies in the patient's room instead of walking in and out of the room every time a supply is needed. It would eliminate a lot of wasted footsteps, and reduce interruptions, distractions, and frustration for staff.

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Participants complained about the difficulty to find equipment in an established place. For example, one of the shift managers noted, “Patient monitoring equipment is constantly missing. We have a hard time relocating it for the next patient because it has been all removed from rooms for the BH patients.” Another nurse reported, “Occasionally equipment and supplies are missing or broken in rooms, slowing down care and creating frustration while caring for patients.”

In many instances, clinical staff found that constant environmental noise correlated with physical and emotional exhaustion, and amplified interruptions and distractions. Staff also noted the importance of visibility for face to face communication. Once visibility was impeded, clinicians “shouted” for communication purposes that escalated noise. To enhance attentiveness in the noisy EDs, staff suggested providing places to “dock away” or “hide.”

Discussion

Working in high pressure and demanding ED environments is overwhelming and challenging for ED staff. Therefore, research is needed to consistently assess and validate design interventions that enhance staff satisfaction and performances. As previously mentioned, there are a few studies that concurrently explore interactions between ED physical environment, attributes (security, wayfinding, visibility, privacy, and efficiency), and desired outcomes. This study found that explored attributes significantly correlated with ED staff performance and satisfaction. This finding suggests that the physical environment elements of EDs that impact different attributes can eventually enhance delivery of care.

Security

Supported by prior findings (Gates et al., 2011; Gharaveis et al., 2017; Pati et al., 2016), security and safety were critical for the ED staff for efficient delivery of care and satisfaction of

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3 the ED environment. Entrances and pathways with direct visibility elevated staff perceptions of
4 safety and control. Having one controlled entrance to the ED department was perceived as a key
5 element for amplified security outcomes. Participants believed that satisfactory visibility,
6 especially around the arrival area, has the potential for enhancing staff perception of safety and
7 satisfaction. This finding illustrates that visibility has a key role on the perception of safety that
8 elevates ED staffs' satisfaction levels.

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10 In line with prior research (Broadbent, Moxham, & Dwyer, 2014; Gharaveis et al., 2017; Pati et
11 al., 2016), micro-modifications for safety enhancements included installing mirrors for greater
12 visibility, metal detectors, or implementing high-impact and bullet-proof glass in registration and
13 nursing station areas.

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Participants perceived the importance of providing an adequate number of security guards in areas with direct visibility to entrance doors who are trained to implement firearms in “code grey” situations with aggressive patients or visitors. In an attempt to modify the security of the medical patient waiting environment, providing a separate, quiet waiting space with sufficient visibility for Behavioral Health (BH) patients was a design recommendation, that is consistent with previous studies (Broadbent et al., 2014; Pati et al., 2016). **These findings indicate the importance of enhanced visibility, controlled traffic, secluded waiting areas for BH patients, and micro-modifications to enhance security outcomes in the ED environment.**

Wayfinding

Ineffective wayfinding and signage causes inefficiency and workplace stress among healthcare providers. Without clear directional signage, patients may wander, become aggressive, fatigued, and abusive to providers (Jiang & Verderber, 2017; Pati, Harvey, Willis, et

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3 al., 2015). Nevertheless, there is a lack of empirical research on the impact of navigation and
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5 wayfinding qualities in hospital-based ED facilities.
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8 **The results found that irregular-shaped and distanced corridors intersections and**
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10 **physical obstructions were identified as structural aspects negatively impacting orientation**
11 **and wayfinding experiences** (Jiang & Verderber, 2017; Marquardt, 2011). Further, having
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13 linear arranged pod configuration is more supportive of movement flows, accessibility, and
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15 connectivity than perpendicular arrangements. Additionally, including waiting areas in direct
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17 visibility of registration spaces is recommended to encourage direct movement that facilitates
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19 wayfinding.
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24 Enhanced waiting systems in the ED were perceived to have a substantial role in staff
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26 work processes and performance. In many hospitals having dedicated or volunteer staff who
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28 escort patients is perceived as providing more personal attention that enhances patient
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30 satisfaction (Brown et al., 2015). This option was also suggested as a solution for enhancing
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32 wayfinding experiences in EDs. However, guiding patients-families to destinations was
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34 perceived as a frustrating, distracting, waste of time and steps (Buffoli et al., 2016). As suggested
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36 by previous research (Jiang & Verderber, 2017; Mustikawati et al., 2017; Pati, Harvey, Willis, et
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38 al., 2015), participants recommended implementing meaningful visual cues and eye-level
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40 signage to improve wayfinding experiences. These findings reflect the importance of **spatial**
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42 **sequences and ER configurations that afford direct access to destinations enhances**
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44 **wayfinding and movement patterns.**
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49 **Visibility**

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51 In agreement with prior studies (Broadbent et al., 2014; Gharaveis et al., 2017; Lu,
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53 Ossmann, Leaf, & Factor, 2014; Pati et al., 2016), the findings show the importance of sufficient
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sightlines to improve visibility towards patients and opportunities for face to face communication that were imperative for staff satisfaction.

The VGA analysis showed that columns, opaque support spaces, and indirect corridors restricted visibility. Team identification, verbal and non-verbal communication, and team coordination were critical factors to enhance perceptions of satisfactory team visibility and work environment. Therefore, participants suggested eliminating columns or walls at check-in, waiting, and POD areas to enhance visibility, safety, communication, and delivery of care. This implication has been also as suggested by previous research (Gharaveis et al., 2017; Pati et al., 2014; Pati et al., 2016).

In line with prior research on nursing unit design (Bayramzadeh & Alkazemi, 2014; Gharaveis et al., 2017; Pati, Harvey, Redden, Summers, & Pati, 2015; Pati et al., 2016; Zborowsky T., Bunker-Hellmich L., Morelli A., & M., 2010), **the enhanced visibility within centralized pods promoted team interaction, communication, a greater sense of cohesion, and interdisciplinary collaboration.** In contrast to centralized pods and corroborating prior literature (Bayramzadeh & Alkazemi, 2014; Pati, Harvey, Redden, et al., 2015), the findings indicate the advantages of decentralized pods for private communication among team members. Supporting prior research (Pati, Harvey, Redden, et al., 2015; Seo, Choi, & Zimring, 2011; Zborowsky T. et al., 2010; Zhang, Soroken, Laccetti, De Castillero, & Konadu, 2015), ED staff perceived decentralized pods improved performance by facilitating access and visibility to patient rooms, enhancing communication, and supporting ease of patient monitoring. The VGA analysis also supported higher visual surveillance in decentralized pods due to the multiple short-distanced perpendicular corridors.

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Advancement in technology communication has relegated the need for proximate distances of care providers (Real, Fay, Isaacs, Carll-White, & Schadler, 2018). However, research suggest providers need for face-to-face communication or information transmission and decision making (Bayramzadeh & Alkazemi, 2014; Gharaveis et al., 2017; Varjoshani, Hosseini, Khankeh, & Ahmadi, 2015). The findings showed that in centralized pods, removing vertical non-transparent barriers were recommended to enhance verbal and non-verbal communication among team members. This is in line with prior literature (Gharaveis et al., 2017; Lu et al., 2014; Pati et al., 2016) . In contrast, **within decentralized pods staff complained about the lack of visibility that impeded team communication and enhanced perceptions of social isolation**, as noted in previous research (Parker, Eisen, & Bell, 2012; Real et al., 2018; Zhang et al., 2015). It can be concluded that the effects of spatial configuration on movement and visibility were consistent with individual perceptions of the spatial affordance.

Privacy

ED staff satisfaction was affected by the level of privacy affordances provided for patients (Broadbent et al., 2014; Gharaveis et al., 2017; Steinke, 2015). Prior studies on EDs suggest that perception of privacy is relegated when patient information is discussed in open treatment areas or workstations (Calleja & Forrest, 2011; Gharaveis et al., 2017; Lin et al., 2013). Supporting previous literature, **staff recommended including allocated enclosed and transparent team spaces as a design intervention for enhancing patient privacy and effective communications**, that has been also recommended in prior studies.

Literature exploring patient's perceptions of ED environments suggest that patients in walled rooms perceive higher levels of privacy and satisfaction (Calleja & Forrest, 2011; Lin et al., 2013). Adding to the body of knowledge on staff perceptions of patient privacy (Calleja &

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Forrest, 2011; Gharaveis et al., 2017), the findings indicated substantial physical improvements for improving ED privacy were having solid walls with doors verses curtains in ERs or triage. Taking this into consideration would offer a more permanent solution for improving patient privacy and confidentiality.

Efficiency

Consistent with prior literature, operational improvement was frequently cited as a substantial factor for optimum care delivery and staff satisfaction (Beck, Okerblom, Kumar, Bandyopadhyay, & Scalzi, 2016). In line with prior studies (Fay et al., 2018; Seo et al., 2011; Steinke, 2015; Varjoshani et al., 2015), participants mentioned the need for the standardized location and replenishment of supplies and equipment within pods, patient rooms, and triage to enhance efficiency, reduce frustration, and improve care.

In line with prior studies, the stressful ambience of the ED inhibited inter-team communication and collaboration (Broadbent et al., 2014; Gharaveis et al., 2017; Varjoshani et al., 2015). High noise levels in the EDs amplified nurses' and physicians' distraction from tasks that was occasionally unsafe and non-patient centric, that is consistent with previous literature (Adkins et al., 2017; Broadbent et al., 2014; Gharaveis et al., 2017).

As described in prior studies (Bayramzadeh & Alkazemi, 2014; Parker et al., 2012; Zhang et al., 2015), **centralized pods were information hubs for disseminating and communicating patient and team updates**. Inherently, these spaces were exposed to noise from conversations, alarms, equipment, tubing, and mechanical systems. Obstructed visibility by support areas also resorted to shouting behaviors for communication. Contrary to centralized pods, decentralized team stations reduced distances and interruptions (Bayramzadeh &

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Alkazemi, 2014; Fay et al., 2018). These results have implications for increasing staff performance and satisfaction.

Conclusions

Findings from this study will serve healthcare facilities professionals, architects, and interior designers in understanding the current challenges of the ED workplace. This knowledge may lead to changes in design guidelines that enhance staff satisfaction and work performance. The findings indicated that higher levels of security, wayfinding, visibility, privacy, and efficiency impacted by physical environment attributes enhanced staff satisfaction and performances (Figure 7). Direct and short-distanced corridors, linear pod arrangements, and unobstructed surveillance towards teams and patients supported team communication, wayfinding, visibility, and security.

Controlled and limited entry points with high visual surveillance towards traffic areas were critical for perceptions of security. Privacy was enhanced by including partitions at registration, team rooms in pods, and ERs with doors. Reducing noise levels, especially in pods, enhanced concentration and team communication. Regarding centralized versus decentralized pod arrangements, each design concept exposed different pros and cons in terms of communication, visibility, and privacy. Therefore, stakeholders need to explore carefully each alternative and select the best option.

"[Place Figure 7 approximately here]"

The primary limitation of the study is the convenience sampling and cross-sectional evaluations. Future studies are recommended to explore multiple EDs with greater spatial layout differences. Another limitation was distributing similar survey links to both sites, and participants having a choice in reporting their work site. Therefore, the survey response data was

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insufficient for statistical site comparisons. Further research is warranted to understand the aspects of the ED environment on other outcomes, such as measured performance outcome, waiting time, staff retention, patient satisfaction, and staff-patient interaction. While the mixed-method application offsets some of the limitations, additional research is required to validate the results and expand the body of knowledge.

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Table 1
Descriptive Statistics on Staff Satisfaction Levels

Themes	Measure	N	M	SD
Operational Outcomes	Bottlenecks	54	2.19	1.12
	Door-to-admission times	54	4.02	1.97
	Door-to-discharge times	53	4.40	1.70
	Access to equipment	55	3.29	1.23
	Access to supplies	54	3.41	1.19
Security	Feeling safe and secure	64	2.70	1.05
Noise	Noise levels	63	2.76	0.89
	Interruption or distraction levels	63	2.70	0.98
	Ease of private interactions with team	64	3.31	1.18
	Private interactions with patients	64	3.66	1.28
	Wayfinding	Wayfinding for patients	36	3.78
Physical Environment Change	Parking for patients	47	3.06	2.30
	Waiting area for patients	53	2.58	1.89
	Check -In area for patients	52	3.10	2.17
	Team work area	54	3.30	2.10
	Pod	50	3.14	1.87
	Coordination and communication	Coordination with team members	64	2.84
Finding team members		64	3.41	1.03
Communicating with team members within pods		64	3.64	1.28
Communicating with team members across pods		63	3.14	1.33
Visibility		Visibly of patients	63	3.60
	Visibly of Team	61	3.69	0.99
	Visibility	64	3.66	0.93

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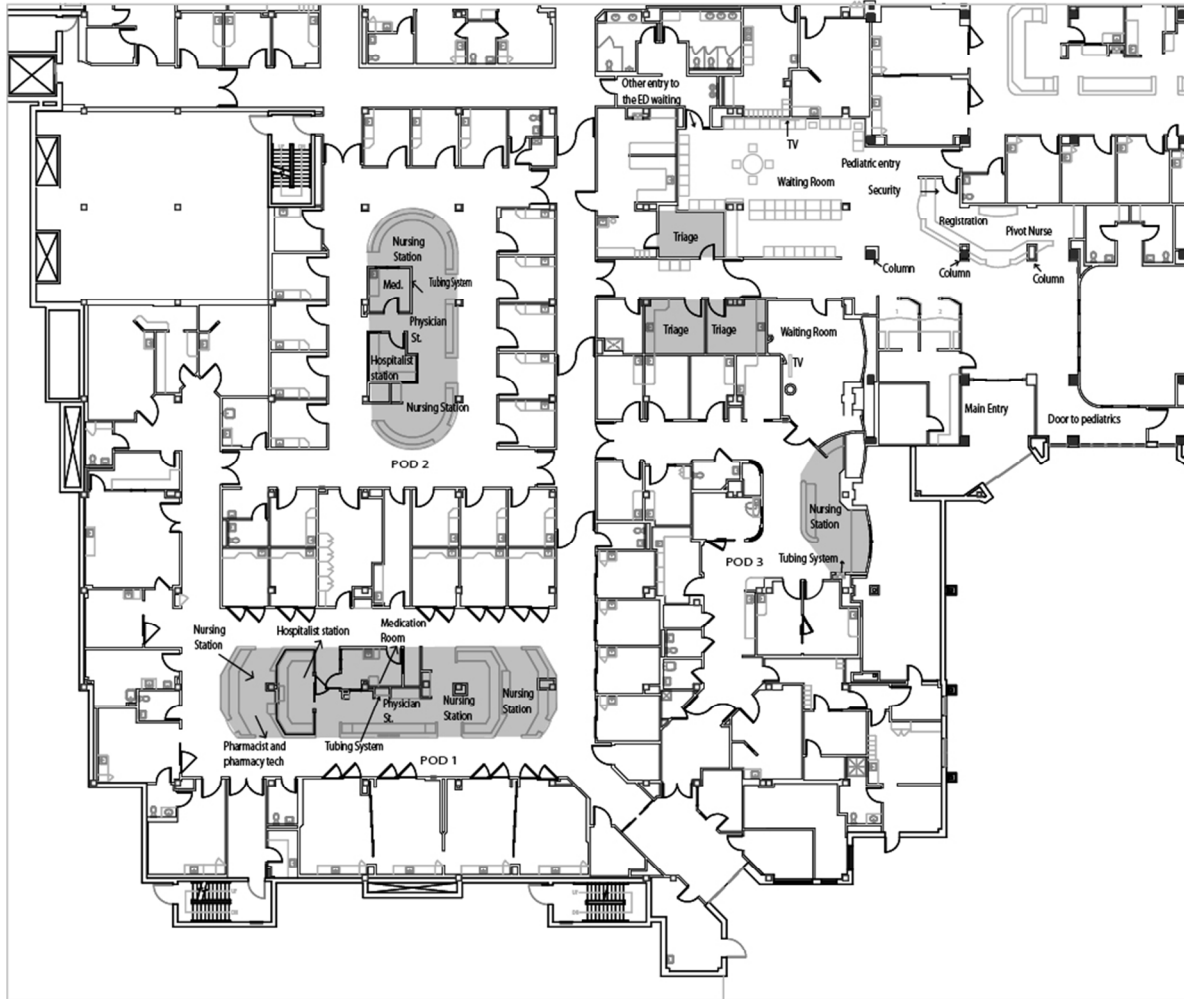


Figure 1. Site 1 with centralized nursing units. As the image displays, medication rooms, physician station, nursing station, hospitalist work room, and tubing systems are positioned adjacent to each other in each POD. Image authorship: author.

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Figure 2. Site 2 with decentralized nursing units. The image displays the dispersed locations of clinical staff work areas (nursing stations, medication rooms, dictation areas, etc.). Image authorship: author.

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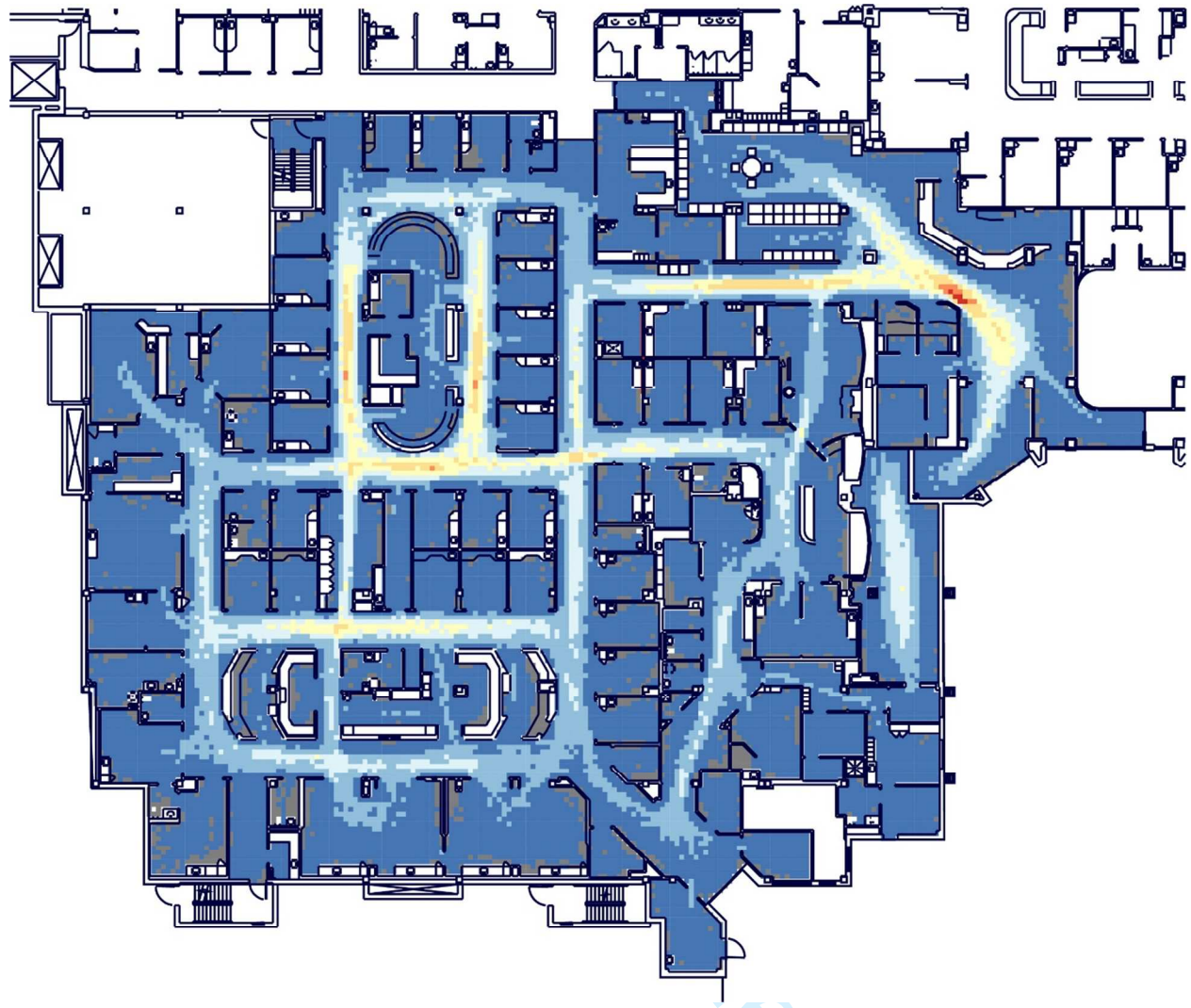


Figure 3. Site 1 agent analysis map. Unbalanced movement patterns due to irregular arrangement of corridors.

Image authorship: author.

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Figure 4. Site 2 agent analysis map. The rectangular unit shape with linear pod alignments and perpendicularly connected corridors enhanced movement and visibility. Image authorship: author.

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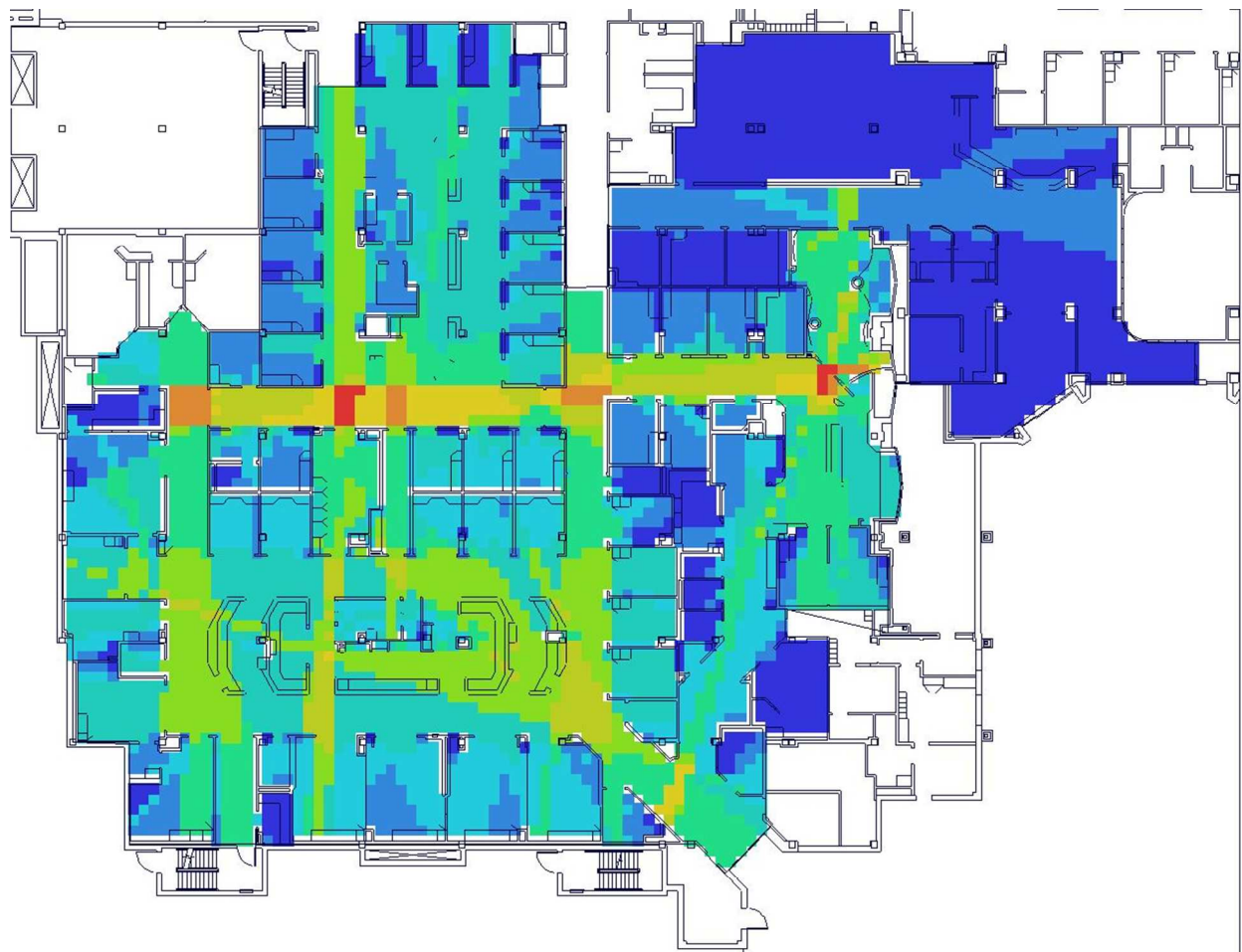


Figure 5. Site 1 VGA map. Columns impeded visibility, especially in the registration, waiting, and POD areas. Image authorship: author.

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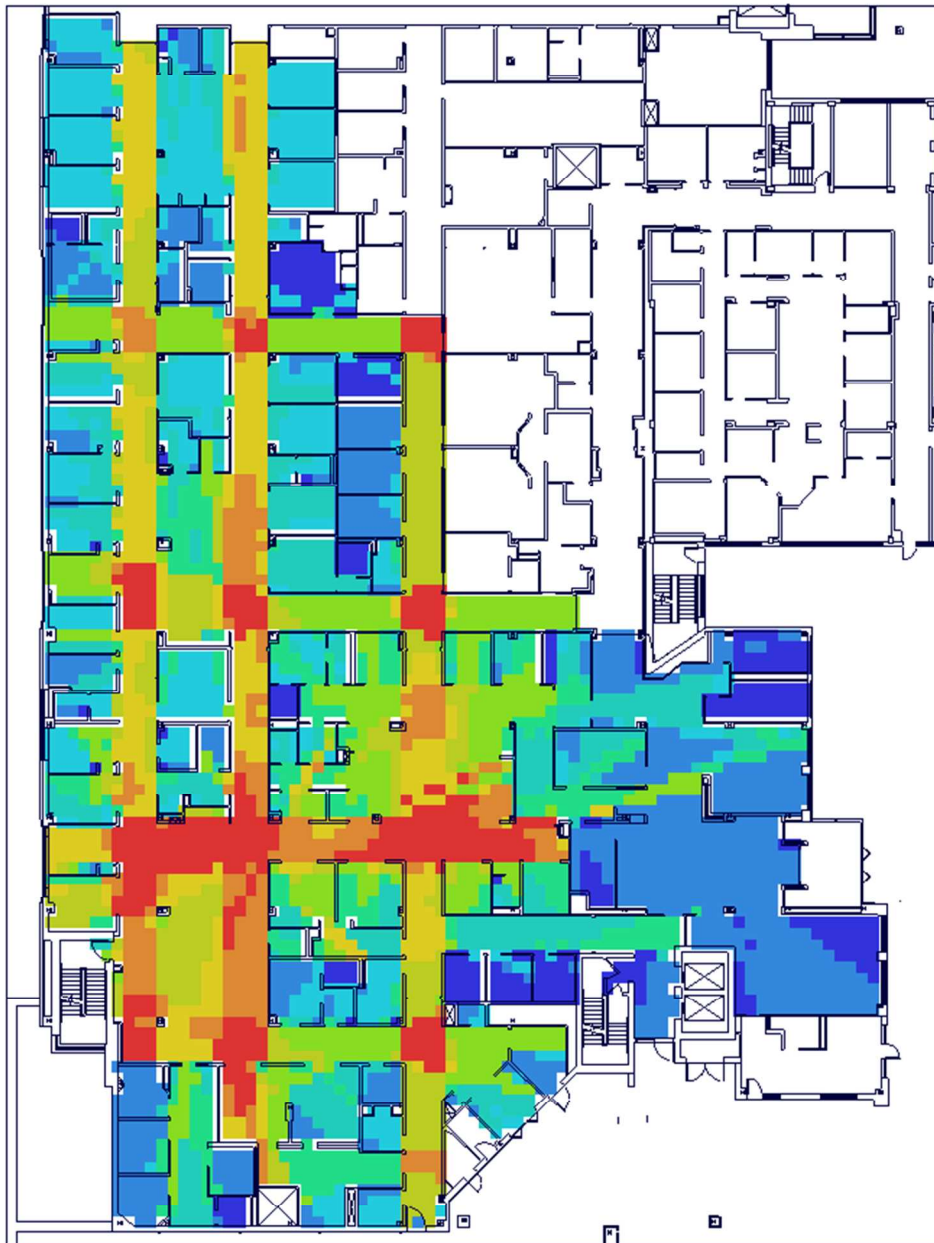


Figure 6. Site 2 VGA map Intersecting corridors at short intervals resulted in higher visibility saturations (red colors) around hallways and nursing stations. Image authorship: author.

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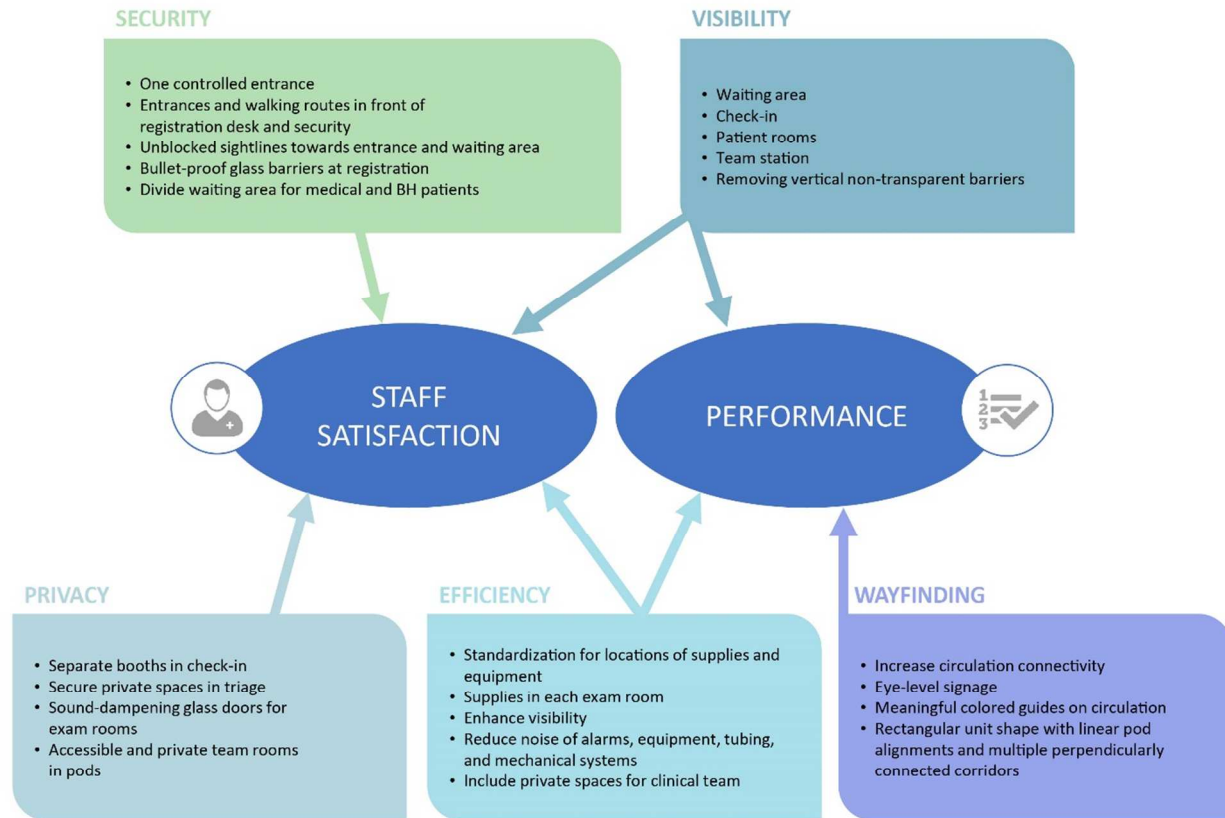


Figure 7. Research Conclusion. The findings established security, wayfinding, visibility, privacy, and efficiency as essential qualities for EDs to achieve safe, efficient, satisfactory, and high-quality outcomes. Image authorship: author.

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Executive Summary of Key Concepts

This research employed a multi-methodological approach to evaluating ED staffs' perceptions of satisfaction and performance impacted by physical design elements. Further, the study explored how the physical environment pertained to their sense of security, wayfinding, visibility, privacy, and efficiency.

Staff considered having multiple entrances with obstructed sightlines as the most fundamental security challenge. Segregating BH patient areas from medical patients in waiting and triage was recommended for enhancing security. Direct corridors from registration to waiting areas and linear pods with directly connected corridors facilitated movement for wayfinding purposes. Staff advocated clear visual sightlines between team members by removing opaque walls, partitions, columns, and glass to improve verbal and non-verbal communication. Short-distanced perpendicular corridors enhanced visibility while columns restricted it. Regarding privacy, ERs with doors and enclosed spaces for team conversations protected patient and team confidentiality.

Acoustic conditions and standardized ERs impacted efficiency levels. Increasing visibility, installing sound-absorbent materials, and providing team discussion areas for reducing noise levels. Also, standardizing locations of equipment and supplies was a contributing factor for efficiency improvement. Security, visibility, privacy, and efficiency were key predictors of staff satisfaction. Further, wayfinding, visibility, privacy, and efficiency impacted staff performance.

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Implications for Practice

Key recommendations for ED space designs include:

- promote security through enhanced visibility, controlled traffic, and dividing medical and BH patient waiting and triage areas (during normal patient volumes);
- enhance wayfinding from parking to entrances, provide adequate eye-level signage and navigation cues, limit entrances, and implement hierarchical pathways;
- use a rectangular unit shape with linear pod alignments and multiple perpendicularly connected corridors to ease movement and enhance visibility;
- limit columns, walls, or blind corners, while maximizing transparent vertical barriers between team spaces;
- maximize privacy by including individual check-in booths, glassed exam rooms, and enclosed team or consult spaces;
- facilitate workflow by enhancing access to supplies and equipment through standardization, movability, and modularity of support core elements; and
- enhance efficiency and reduce distraction by controlling and relegating noise levels produced by equipment, voices, and interruptions.