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Exploring the Effects of Clinical Exam Room Design on Communication, Technology Interaction, and Satisfaction

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Abstract

Objective: This article evaluates the effects of technology integration and design features in clinical exam rooms on examination experiences, communication, and satisfaction. **Background:** Exam room features can affect the delivery of patient-centered care and enhance the level of communication, which has been shown to directly impact clinical outcomes. Although there has been an increasing body of literature examining design and patient-centered care, little research has evaluated the extent to which information sharing and electronic health record (EHR) interaction are impacted. **Method:** The research randomly allocated 22 patients, 28 caregivers, and 59 clinicians to simulated clinical encounters in four exam room mock-ups with semi-inclusive, exclusive, and inclusive layouts (128 sessions in 32 scenarios). Video recordings of the simulations were coded for clinician gazing, talking, and EHR-interaction behaviors. Participants also completed surveys and answered open-ended questions after experiencing each scenario ($N = 362$). **Results:** Semi-inclusive rooms with a triangular arrangement of consultation table, sharable screens, exam table, and caregiver chair were highly preferred as they supported conversation, gazing, and information sharing. The *inclusive* layout had higher durations of EHR interactions and enhanced viewing and sharing of EHR information. However, this layout was criticized for the lack of clinician-shared information. The *exclusive* layouts impeded information sharing, eye contact, and constrained simultaneous data entry and eye contact for clinicians. The distance and orientation between chair, exam table, curtain, and door were important for protecting patient and family comfort and privacy. **Conclusion:** Characteristics and configurations of design qualities and strategies have a key role on examination experiences, communication, and satisfaction.

Keywords

clinical exam rooms, information sharing, technology integration, patient-centered care, exam room furniture, eye contact, furniture orientation, satisfaction

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Patient-centered treatment can be defined as care that recognizes the patient's requirement and health outcome as the primary influence for healthcare choices and quality dimensions (Ajiboye, Dong, Moore, Kallail, & Baughman, 2015; Gorawara-Bhat & Cook, 2011). The quality of collaborative, coordinated, and accessible care is substantial for patient-centered care delivery and affected by the patient-physician communication experience (Ajiboye et al., 2015; Lee, 2011). Communication is defined as the act of transferring information by different means: verbal (talking); non-verbal (gazing); or visualized (EHR information shared and viewed by monitors) (Asan, Young, Chewning, & Montague, 2015; Kazmi, 2014).

Recent literature indicates that clinician eye-contact (gaze) with patients is a significant predictor for perceptions of enhanced patient-centered communication and patient satisfaction (Gorawara-Bhat & Cook, 2011). Furthermore, establishing eye-contact between the clinician and patient is linked to patients' perception of higher levels of clinician communication, empathy, attention, and warmth (Asan, Xu, & Montague, 2013; Bonner, Simons, Parker, Yano, & Kirchner, 2010).

The increased integration of the Electronic Health Record (EHR) in healthcare practice suggests the importance of understanding how technology-mediated clinical exam rooms impact patient-caregiver-clinician communication and behavioral dynamics (Ajiboye et al., 2015; Asan et al., 2013; Asan et al., 2015; Bonner et al., 2010; Gorawara-Bhat & Cook, 2011). There is some controversy regarding the impact of EHR on clinical examination experiences. Several studies found that EHR integration inhibits clinician's continuous attention on patients, delays communication, and impairs patient-clinician relationships (Ajiboye et al., 2015; Asan, D Smith, & Montague, 2014; Bonner et al., 2010). On the other hand, other literature suggests that opportunities for EHR information sharing promotes patient engagement, satisfaction,

interaction, and attention for shared decision-making (Ajiboye et al., 2015; Almquist et al., 2009; Asan et al., 2014; Asan et al., 2013; Asan et al., 2015; Chen, Ngo, Harrison, & Duong, 2011; Unruh, Skeels, Civan-Hartzler, & Pratt, 2010).

For example, Ajiboye et al. (2015) evaluated a traditional exam room with an experimental room that provided equal access to the laptop computer screen. Findings showed that patients were more likely to have an excellent encounter and were more satisfied with the seating position of the physician in the experimental room versus the traditional room setup. In the experimental condition, participants perceived enhanced computer accessibility, inter-personal interaction, provider information sharing, and more time engaged in a conversation with the provider. Asan et al. (2013) research indicated the technology-centered rooms with physicians over-relying on technology had the shortest gaze between patients and physicians by a significant margin ($p < .05$).

Kumarapeli and de Lusignan (2012) classified consultation room layouts into four categories: (a) *Inclusive*: clinicians and patients share computer screens; (b) *Semi-inclusive-patient-controlled*: patients have control and can view screen comfortably; (c) *Semi-inclusive-clinician-controlled*: clinician has control over screen access and patients must turn or move, or screen must be rotated for content sharing; and (d) *Exclusive*: patients are located at the opposite position without screen access. Findings showed that a combination of room layout and the physicians' actions influenced patients' gaze towards the EHR. In the semi-inclusive-clinician-controlled layouts, screen sharing was not noticed and clinicians were less likely to look at the computer versus the semi-inclusive-patient-controlled layout.

Age and level of clinical experience variations may also impact perceptions and competence with the EHR-interaction and patient-centered communication. For instance, Piper

and Hollan (2013) observational prototype tests indicated that viewing charts and images from the EHR improved communication and data interpretation for older patients. Literature also suggests that physician EHR training improves EHR-associated communication skills, physician-patient relationship, and provider confidence (Lanier, Cerutti, Dao, Hudelson, & Perron, 2018).

Clinical patients spend most of their time and interaction within the exam room. Therefore, the physical environment and design of exam rooms is an important factor for the overall satisfaction and delivery of care. Typical examination room layout is clinician-centered and mostly lacks design features for successful patient-physician communication (Ajiboye et al., 2015; Almquist et al., 2009). Despite the increasing amount of research in the wider scope of technology-integrated exam rooms, there has been little exploration of the role of room design and furniture configuration's impact on communication, EHR-interaction, and satisfaction to inform design decisions. Therefore, this explorative study aims to address the following questions: Q1: Do the exam room's layout and technology arrangements affect communication behaviors and EHR-interactions? Q2 What, if any, is the relationship between satisfaction levels of examination experience, communication, information sharing, and exam room features? Do satisfaction levels vary by user type?

Methods

This study deployed an exploratory mixed-methods approach that included quantified observation of behaviors, surveys, and qualitative analysis of open-ended responses. All research protocols were designed and evaluated for compliance with the Institutional Review Board (IRB) of the hospital setting where the research occurred. The researchers randomly allocated 22 patients, 28 caregivers, and 59 clinicians to simulated clinical encounters in 4 exam room

architectural mock-ups. Participation was voluntarily and patients, families, and clinicians were recruited by an email that explained the study purpose, approach, and data confidentiality.

The researchers placed video cameras in unobtrusive locations in each examination room, recorded each simulation and later analyzed video recordings to determine the duration and frequency of examination stages, communication patterns (gazing and talking), and EHR-interaction. The observational method followed a within-subject experimental design in which the participants were randomly assigned to exam rooms. Sessions were performed on four consecutive days and in eight different time slots. To address carryover effects, the study employed a counterbalancing approach in which the orders of experiencing exam rooms differed in each day and were randomly distributed. The randomization design schedule consisted of four room orders within four days for each patient type (16 pediatrics or 16 geriatrics), resulting in 32 total scenarios and 128 sessions.

Participants also completed surveys and answered open-ended questions after experiencing the clinical scenario in each mock-up. The pilot survey was tested before the actual scenario and refined. The survey explored levels of satisfaction in four categories: (a) examination stages; (b) communication with MD or MA; (c) information sharing and viewing of monitors (visual communication); and (d) room features. Examples of survey questions are presented in Table 1. Questions were on a 7-point Likert scale, with anchors at 1 = Very dissatisfied; 4 = Neither satisfied nor dissatisfied; and 7 = Very satisfied. Additionally, open-ended questions explored participants' perspectives of liked or disliked exam room features.

[Place Table 1 approximately here]

Demographic characteristics were not collected due to hospital policies; however, gender information was later retrieved from the videos (detailed findings are reported in supplementary

files). Participants included patients (n = 11), patient actors (n = 11), caregivers (n = 12), caregiver actors (n = 16), medical doctors (MDs) (n = 22), and medical assistants (MAs) (n = 37). Actors were hospital staff members who played various roles, defined by the scenario simulation script in case of patient or family unavailability. These role assignments did not impact the validity of results, as any healthcare staff member could be or have been a patients or families in real life.

Setting

Four exam room prototypes were approved and developed for full-scale construction on a vacated floor of an existing hospital building. As illustrated in Figure 1, each exam room had a different taxonomy, configuration, and somewhat similar furniture. Room A (RA) and room D (RD) had a semi-inclusive clinician-controlled setup, Room B (RB) an exclusive, and Room C (RC) an inclusive configuration. The exam room designs were Owner/Designer preference for this exploration. Each design was evaluated and selected based on the owner's criteria including but limited to the inclusion of current design standards, projected budget, designation of clinical practices to be present in the actual setting, current and future electronic health record technology.

[Place Figure 1 approximately here]

Analysis

The Behavioral Observation Research Interactive Software (BORIS) was implemented for event logging and video coding of observations. Behaviors were defined as state events (with durations) or point events (no duration). Exported codes included these segments: subject, examination stage, behavior, and modifier (point events linked to behaviors). Subjects coded during the video analysis included physician (MD) and medical assistant (MA). Sessions were

coded for the following clinical examination stages of interest: (1) MA intake: MA initiates questions and enters data in the computer (excluding blood pressure and examination); (2) MD information gathering: physician conversation with patient or family about the patient's health status; (3) MD physical examination: MD starts adjusting the exam table, performs examination, and rearranges the exam table; and (4) MD diagnosis-patient education: MD enters exam results in EHR system, explains the examination results, educates the patient, and discusses future care.

Observed behaviors were classified into the following categories: (a) Gazing: mutual gaze between the clinician, patients, families, or both as an indication of attention and communication (Asan et al., 2014; Montague & Asan, 2014); (b) EHR-Interaction: clinician application of keyboard, mouse, or monitor screens to read or enter data; and (c) Talking: the duration of clinician engaging in a conversation with the patient or family. Researchers also coded if the patient, family, or both were the point of focus for clinician gazing or conversation (as a point data described as a modifier in the BORIS software). For instance, when the provider (MA or MD) and patient mutually gazed at each other, the interaction was coded as follows: provider as the subject; behavior: eye-contact; and modifier: patient. Training in the instrument implementation occurred to ensure the reliability of findings. The proportion of agreements and Cohen's Kappa coefficients were employed to analyze reliability values until inter-rater reliability scores reached .67.

Due to time restraints for coding the entire videos, sessions were divided into examination stages and stages were randomly selected to represent different patients and exam stage across rooms. Researchers separately coded the three defined behaviors within the examination stages, with the ability to start and stop recording when the behavior was paused or interrupted for instance by another person, searching behaviors, or starting vitals. These pauses

created behavioral segments. That is, if within an examination stage the observed behavior was stopped, one behavioral segment was created. The total number of behavioral segments were representative of behavior disconnection.

The resulting sample after data randomization sampling included nine geriatrics and 12 pediatric sessions that ranged in different rooms (RA n = 16, RB n = 15, RC n = 16, and RD n = 13). The sample represented the following stages (N = 258): MA intake (n = 67, 26%); physician diagnosis-education-referral (n = 73, 28.3%); physician information gathering (n = 77, 29.8%), and physician physical exam (n = 41, 15.9%). The data included 53.1% (n = 137) adults and 46.9% (n = 121) pediatrics data values performed by physicians (n = 191, 74%) and MAs (n = 67, 26.0%).

To evaluate the nature of examination stages per observed behaviors, codes were structured into three categories: (a) Behavioral Duration per Examination Stage (BDS): total duration of a behavior (talking, gazing, or EHR-interaction) for each examination stage ; (b) Behavioral Segments per Examination Stage (BSS): resulting from discontinuity of the behavior, this number presented the total number of behavior segments (start-stop units) observed in an examination stage; and (c) Total Behavior Duration per Session (TBS): total duration of the three coded behaviors across the four examination stages of a session. Additionally, gazing and talking behavior durations were merged to identify patient-clinician or family-clinician interactions.

All statistical analysis was conducted using the SPSS software. Descriptive statistics are presented as means and standard deviations (in parenthesis next to average values) for continuous variables, frequencies, and proportions for categorical variables. One-Way ANOVA and post-hoc tests analysis were performed to understand significant differences between rooms.

The open-ended responses were content analyzed and audited using standard content analysis techniques. A minor difference between the coders was resolved by collective reviewing. Responses were analyzed to identify perspectives and underlying reasons for satisfaction ratings on examination stages, room features, communication, or information sharing.

RESULTS

Observational Findings

The average duration of the examination sessions, including MA vital intake, wait and gowning times, was 540.67 seconds (aggregated data across all room types). Average duration of all four exam stages was 377.93 (aggregated data across all room types). This number excludes MA vital intake, waiting, and gowning times. Average durations of each exam stage for adult patients were: MA intake = 91.05 (55.80); MD info-gathering = 89.99 (36.90); MD exam = 158.43 (96.41); and MD education and referral = 96.41 (14.67); Total = 435.86. For pediatric physical exam, average durations of examination stages were as follows: MA intake = 76.75 (35.00); MD info-gathering = 56.50 (27.27); MD exam = 127.52 (50.95); and MD education and referral = 55.75 (35.39); Total = 316. 52. Durations of MD info-gathering and MD education significantly differed between patient types, $F(1,22) = 6.39$, $p = .019$, $F(1, 21) = 14.17$, $p = .001$.

Aggregated data across all room types showed Talking duration ($M = 104.7$), and eye-contact ($M = 83.39$) were longer than EHR-interaction (M = 35.59) and this difference was significant, $F(2, 136) = 18.078$, $p < .001$. The ANOVA analysis indicated significant difference between room types and average BDS, $F(3, 251) = 3.44$, $p = .017$ (RA $M = 37.75$ (28.79); RB $M = 39.75$ (29.98); RC $M = 53.79$ (36.43); RD $M = 37.55$ (33.38)). RC had significantly higher

duration of behaviors than RA and RD ($p < .05$). There were no significant variations across rooms in the average BSS or TBS values. The results showed no significant difference comparing the average BDS, BSS, and TBS values for the two patient types in rooms.

Rooms did not significantly differ in the average TBS or BSS for talking, gazing, or EHR-interaction values. Average BDS values for talking or gazing were not significantly different across rooms. However, statistical analysis showed significant variations among BDS values for EHR-interaction across rooms $F(3, 55) = 4.80$, $p = .005$(RA $M = 18.37$ (13.17); RB $M = 22.46$ (13.58); RC $M = 49.84$ (49.32); RD $M = 16.95$, (15.25)). Tukey HSD comparisons indicated that RC had longer EHR-interaction BDS than RA, RB, and RD ($p < .05$).

Data analysis explored BDS values for talking, gazing, and EHR-interaction per the four examination stages across rooms. ANOVA analysis indicated no significant difference across rooms, except the average duration of EHR-interaction during MA intake, $F(3, 17) = 5.034$, $p = 0.01$. Tukey HSD Test indicated that RC had significantly longer EHR-interactions during MA intake, in comparison to RA and RB ($p < .05$). Descriptive results showed that clinician interactions occurred mainly with patients, and subsequently patient-caregiver, and then caregiver (59.6%, $n = 115$; 21.24%, $n = 41$; 19.17%, $n = 37$, respectively). BSD and BSS values during interactions were not significantly different across rooms.

Survey Findings

Average time for survey completion was 15 minutes and 13 seconds (MD $n = 123$, 34.0%; MA $n = 89$, 24.6%; Family $n = 89$; 24.6%; and patient $n = 61$, 16.8%, N = 362). Overall satisfaction with examination stages and communication levels was high (5 and above), with no significant difference between rooms.

The findings show that satisfaction with monitor-sharing and viewing information on the monitor significantly differed across rooms (monitor-sharing RA $M = 4.03$ (2.83); RB $M = 2.66$ (2.5); RC $M = 4.96$ (2.47); RD $M = 4.22$ (2.86); $F(3, 348) = 14.19$. $p > .001$; viewing information on monitor RA $M = 4.95$ (2.6); RB $M = 3.54$ (2.7); RC $M = 4.84$ (2.44); RD $M = 4.76$ (2.68); $F(3, 346) = 6.58$. $p > .001$). Tukey's test showed that RB had significantly the lowest ratings for sharing and viewing information on the monitor ($p < .001$).

Satisfaction ratings for MA or MD communication with patient or family were not significantly different across rooms. Table 2 displays significant predictors of satisfaction with communication between MD, patient, and family members across rooms. As displayed, satisfaction with the MD examination was affected by perception of communication level and exam room features, such as the MD workstation, wall monitor, and computer monitor.

[Place Table 2 approximately here]

Table 3 displays room features with significant satisfaction ratings. Tukey's analysis indicated that average ratings for the computer monitor in RB were significantly lower compared to RA ($p = .002$), and RD ($p = .001$). Also, RC represented significantly lower ratings for computer monitor, compared to RA ($p < .001$) and RD ($p < .001$). RB had significantly lower mean ratings for satisfaction with the wall monitor ($p < .001$) and exam table ($p < 0.05$), compared to other rooms. Post Hoc tests showed that RD represented the highest satisfaction ratings for the physician workstation table, compared to other rooms ($p < .01$). Satisfaction with the curtain configuration ranged significantly in exam rooms. RD had significantly higher ratings for the curtain configuration compared to other rooms ($p < .05$). Further RA had significantly lower curtain configuration ratings compared to RB or RD ($p < .05$).

[Place Table 3 approximately here]

Table 4 displays descriptive values for variables that significantly differed across rooms by user type for examination stages, communication, information sharing, and room features (for this study only relevant features are disused.) For MDs, the following attributes significantly differed: RC and RB the least for the computer monitor and wall-mounted monitors, respectively, compared to other rooms. MD workstation in RD was more favored than RC. The curtain configuration in RD was rated higher than RA and RC.

[Place Table 4 approximately here]

For MAs, the computer monitor configuration in RB had lower ratings than RA and RD. RB was the least favored for wall-monitor configuration, compared to other rooms. For family members, RC had higher ratings than RB for information-sharing on monitor, with RB the least favored across all rooms for information-viewing, wall-monitor configuration, and exam table. The curtain in RD was rated more satisfactory than in RA. For patients, RB was the least favored for information-sharing, information-viewing, computer monitor, wall-mounted monitor, and exam table across all rooms. Also, patients favored RD more than RA for curtain configuration and the MD workstation. Overall, all participants had higher satisfaction with RD and low satisfaction ratings for RB.

Open-Ended Findings

Table 5 presents examples of liked or disliked physical features, associated attributes, and possible outcomes. Table 6 displays total frequency of negative or positive comments based on room type and associated outcomes. Figure 2 and 3 display findings based on room type, physical features, and associated outcomes (Figure 2 and 3).

[Place Table 5, Table 6, Figure 2 and 3 approximately here]

The triangular setup in RA and RD was the most preferred because it supported eye-contact, communication, and monitor information sharing opportunities. Physicians favored the ability to maintain eye-contact while entering EHR information in RA and RD. The clinicians favored the shape of the MD workstation and its orientation towards the exam table that provided minimal distance between the provider and patient, facilitating conversation and monitor sharing. The exam table position was the most favored feature in RB, as it provided adequate room for examination, was near the caregiver chair, and afforded eye-contact opportunities when the provider entered the room.

In RC, the multiple wall-mounted monitors were a preferred feature. Comments inferred that information sharing was enhanced by the "readable fonts." Additionally, the monitors were considered a positive distraction in the exam room. Conversely, some participants disliked the wall-mounted monitor information sharing in RC who perceived it as "overwhelming," "expensive," or "unnecessary." The clinicians were concerned about liability issues for sharing sensitive information and violating HIPPA policies (n = 10). Physicians also favored the mobile workstation and wireless keyboard in RC that enhanced maneuvering and flexibility during EHR entry.

The inadequate distance between clinician workstation and exam table in RA resulted in the most negative comments on furniture positioning, indicating that it resulted in uncomfortable maneuvering, tripping hazards, furniture movements, and inefficiency. The exclusive layout of RB had the highest number of negative comments on face-to-face communication, information sharing, and patient comfort. Participants criticized the location of provider workstation in RC in relation to the monitors. Providers needed to continually turn around to read the screens. Further, providers found that facing the wall-mounted monitors was an "inconvenience." RC was also

disliked for the caregiver chair location as it was uncomfortably close to the door, curtain, and exam table. Its location also restricted eye-contact opportunities with clinicians during the examination. RD had the highest frequency of negative comments impacting patient safety and comfort due to the opposite positioning of caregiver chairs in relation to the exam table, which was criticized for impeding patient privacy and safety.

Discussion

This paper underscores the salience of physical attributes of exam rooms in supporting patient-centered care by impacting communication, EHR-interaction, and satisfaction outcomes. Total Behavior Duration of EHR-interaction was less than talking or gazing. This may be due to participants entering scenario-scripted information in computers, whereas in real-life instances more focus, experience with EHR technology, and attention are required to enter data and prevent possible errors (Kazmi, 2014). Clinicians had to continually look back and forth between the EHR screen and the patient and caregiver resulting in longer BDS durations in RC. Further, the lack of dedicated computer monitors was an obstacle towards simultaneous eye-contact and EHR-entry, reducing satisfaction and efficiency.

The results of this study indicate the active role of computers monitors, and more specifically wall-mounted screens, in information sharing and decision making during clinical visits. RA and RD were highly favored for the positioning of the wall monitor, clinician workstation, and the exam table. **This triangular arrangement promoted face-to-face communication, active information sharing, and simultaneous EHR entry. It also enabled concurrent data entry and eye-contact for the clinician.**

Similar to previous studies (Ajiboye et al., 2015; Almquist et al., 2009; Asan et al., 2015; Kumarapeli & de Lusignan, 2012; Unruh et al., 2010), **the inclusive layout of RC was highly preferred for information-sharing and interaction facilitated by the size and quantity of wall monitors in the room.** Nevertheless, clinicians were concerned about inability to control what information is shared on the monitors which could jeopardize patient privacy, as found in prior studies (Asan et al., 2015) (Bonner et al., 2010; Dowell, Stubbe, Scott-Dowell, Macdonald, & Dew, 2013; Margalit, Roter, Dunevant, Larson, & Reis, 2006). Consistent with prior studies on exclusive layouts (Asan et al., 2015; Milne et al., 2016; Unruh et al., 2010), the lack of wall-monitors for information-sharing with patients and families in RB resulted in promoted passive patients and was highly disliked by all participants.

Sharing and viewing information on monitors, as well as the orientation of MD workstation and wall monitors, were predictors for communication between MD, patient, and families. The findings showed that across all rooms, designing opportunities for patient-interactions through room layout should be prioritized for achieving a patient-centered experience. Studies show that physician gaze highly impacts patient gaze, and thus focusing on EHR information decreases potential eye-contact with patients (Almquist et al., 2009; Asan et al., 2013; Montague & Asan, 2014). When clinicians in RB focused on EHR-entry with their back towards the patient, eye-contact was reduced. This exclusive layout was identified as "impersonal" as it discouraged patient-centered communication, eye-contact, and information-sharing. This corroborates previous literature (Gorawara-Bhat & Cook, 2011; Kazmi, 2014; Kumarapeli & de Lusignan, 2012; Milne et al., 2016; Montague & Asan, 2014).

In RC, computer screens were defined as distractions. In contrast, the semi-inclusive rooms (RA and RD) were highly preferred as they facilitated provider-computer-patient-family

communication and information sharing. In this room, the clinician controlled the extent of data-sharing displayed on the wall monitor and could position their keyboard workstation in various ways for data entry. In RA some participants, especially patients, mentioned that the close distance between workstation and exam table felt uncomfortable during the examination. In RC, the workstation was portable but not positioned for optimum wall monitor viewing, and in RB, the workstation was at the corner of room limiting EHR sharing and eye-contact. This result shows the importance of the workstation orientation for enhanced gazing and monitor sharing.

Satisfaction with exam tables has been linked to satisfaction with the facility, perceived quality of care, and approach behaviors (Lee, 2011). The results of this study offer new empirical insight on how the orientation and usability of exam tables also had major impacts on satisfaction. In RA, participants were dissatisfied about the positioning of the exam table in the mid-section of the wall as it resulted in space redundancies. Further, the exam table located at the front of the consult table yielded a tight space for maneuvering during examination thus reduced throughput. For families and patients, the exam table in RB was the least favored, compared to other rooms. Reflecting on usability issues, families of pediatric patients and older patients complained about the difficulty of getting onto the exam table due to its high positioning. Participants were unable to alter the exam table configuration and in RB the exam table was armless with manual adjustments Also, during pelvic exams the stirrups were too close to family chairs. The orientation in relation to MD workstation impeded eye-contact between providers and patients and was unfavorable.

Integrating positive distractions in healthcare environments is associated with enhancing patient mood and satisfaction, as well as reducing anxiety, pain, and the perception of waiting time (Nanda et al., 2012; Schneider, Ellis, Coombs, Shonkwiler, & Folsom, 2003). In line with

prior literature (Corsano, Majorano, Vignola, Guidotti, & Izzi, 2015; Schneider et al., 2003), participants mentioned that multiple monitors in RC facilitated "the passing of time" and provided a "positive distraction." This underlines the importance of incorporating dynamic, interactive, and informative technology components as a positive distraction.

During the clinical exam, triangulation changes as patients, family, and clinicians move through different stages. Figure 4 demonstrates the how triangulation in each room is altered from the starting stage of the exam, (hand-washing upon clinician's entry) to information gathering. **Rooms that maintain the relative angles between the participants and between stages, support transition as the clinician moves in the room and help to keep the continuity of the conversation, by minimizing the disruption of repositioning.** The qualitative findings highlighted the importance of furniture distances and adjacencies in exam rooms to enhance performance and comfort. For instance, participants in RD criticized that the "too close" distance of furniture produces tripping hazards for participants. Having the chair at the corner of RD made some caregivers feel "left out" of the examination process. Patients in RC favored sitting next to caregivers while observing the wall monitor information. However, the location of caregiver chairs was the least favored as it was proximate to the door swing, curtain, and exam table, and impacted flow and comfort.

[Place Figure 4 approximately here]

Adjustable and flexible furniture was an important consideration for achieving satisfactory evaluation. The fixed consult table in RD was not favored and was perceived as a limitation for monitor sharing and communication. However, being able to readjust computer monitors using adjustable swivels diminished this barrier, as suggested by prior studies (Chen et al., 2011). RD had higher satisfaction ratings for the positioning of the curtain. RD's curtain

location effectively separated the patient zone from family or clinician zones and did not interfere with any room furnishings. RA's curtain had the lowest rating across all participants as the family and patient zone were on the same side forcing the family to walk next to the door during the exam. RA was perceived as not protecting patient privacy as patients were not shielded from the door by a curtain.

Limitations and Directions for Future Research

This study has limitations. In response to client contracts, researchers were not able to test a semi-inclusive patient-controlled layout. Further, due to a lack of resources, researchers were unable to code all the collected videos, so randomization was employed to retrieve an acceptable sample. Demographic data was not retrieved to ensure patient, caregiver, and clinician privacy. It would be interesting to explore the impact of age, gender, and ethnicity in satisfaction and communication outcomes in relation to room layouts. Although observer reliability was at an acceptable level, modifying the methodology and coding descriptions may enhance reliability in future studies. In real-time clinic visits, interruptions and distractions may impact examination and behavioral durations or segmentation. Additionally, clinicians from different areas of expertise may use different examination methods from those we explored. More research is needed to explore different communication and satisfaction outcomes in various medical specialty contexts and with diverse layouts affected by design features in exam rooms. In future research, diverse patient types and demographics should be explored. It would also be interesting to validate the results obtained in this research through pre-occupancy and post-occupancy assessments through the design of new clinical exam rooms.

Conclusion

Exam room layout modification provides a great capacity to increase communication, EHR-interaction, and satisfaction in clinical exam rooms. Semi-inclusive physician-controlled configurations increased eye-contact and encouraged patient-caregiver involvement in discussions. The computer in this layout was appreciated as it supported patient privacy during information sharing. Inclusive layouts promoted interactions between clinicians, patient, and technology. However, participants emphasized the value of a balanced and effective technology integration that is not overwhelming for the patients and protects patient privacy. The lack of opportunities for viewing and sharing information in the exclusive layout negatively affected the clinician's capability to establish eye-contact and attentiveness towards them.

In terms of furniture arrangement, the results show that triangular configurations for the exam table, clinician table, and caregiver chairs were highly preferred. This orientation contributed to comfortable encounters, efficiency, eye-contact, and effective information sharing. Patients reflected the need for proper orientation of exam table in relation to family chairs, curtains, or doors to enhance perceptions of privacy and comfort. **These findings suggest the importance of comfortable and acceptable distance between furniture (especially MD workstation, exam table, and chairs) to reduce flow disruptions and enhance comfort.** The results of this study suggest that RD had the best layout configuration for patient-centered outcomes. Figure 5 suggests changes to RD in response to the participant comments. In the edited RD exam room, repositioning the sink in the circulation path of the clinicians promotes hand hygiene. An additional monitor placed 90 degrees from each other, supports a triangular relationship between patients, family, and clinicians as well as, ease of maintaining eye-contact during information sharing (Figure 6). Further, the revised position of the curtain and family

seating supports privacy and comfort. Overall, this research contributes to the body of knowledge and adds new perspectives regarding behaviors and preferences impacted by different exam room layouts.

[Place Figure 5 and 6 approximately here]

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Table 1.
Example of survey questions.

Category	**Scaled Questions**
	On a scale of 1 to 7, with 1 being "Very Unsatisfied" and 7 being "Very Satisfied," overall how satisfied were you with:
Examination Stages (6 items)	intake with Medical Assistant? gowning? physical examination? prescription of medications? tele-visit/consult? immunization?
Communication (4 items)	communication between the Medical Assistant and Patient? communication between the Doctor and Patient?
Information Sharing (2 items)	sharing of information on the monitor viewing information on the monitor
Room Features (30 items)	wall-mounted monitor? computer monitor? exam table? family chairs? curtain?

Table 2.

ANOVA analysis results of significant predictors for MD communication with patients or family.

		β	F
	Satisfaction with MD Communication with patient		
RB	MD workstation	0.30	7.91*
RC	Wall-mounted monitor	0.29	11.68**
	Sharing Information on monitor	0.27	
RD	MD workstation	0.59	23.28**
	Viewing information on monitor	0.26	
	Satisfaction with MD Communication with Family		
RA	Sharing information on monitor	0.23	4.28
RC	Wall-mounted monitor	0.29*	9.73**
	MD Workstation	0.26	
RD	Physician workstation	0.54	22.04**
	Viewing information on the monitor	0.24*	

$p < .05$. *$p < .01$., **$p < .001$

Table 3.

One-way ANOVA analysis on satisfaction with exam room features.

Satisfaction Rating	**RA Mean (*SD*)**	**RB Mean (*SD*)**	**RC Mean (*SD*)**	**RD Mean (*SD*)**	***F***
Monitor sharing	4.03 (2.83)	2.66 (2.5)	4.96 (2.47)	4.22 (2.86)	14.19***
Monitor information viewing	4.95 (2.6)	3.54 (2.7)	4.84 (2.44)	4.76 (2.68)	6.58***
Computer monitors	5.72 (1.61)	4.90 (2.13)	4.35 (2.59)	5.86 (1.49)	10.16***
Wall-mounted monitor	4.58 (2.7)	.63 (1.8)	4.81 (2.42)	4.71 (2.73)	76.48***
Exam table	4.83 (2.16)	4.30 (2.1)	5.61 (1.60)	5.65 (1.52)	12.13***
Physician workstation	4.48 (2.36)	4.50 (2.14)	4.31 (2.39)	5.60 (1.83)	6.61***

*** *p <.001*

Table 4.

Significant satisfaction average (M) and standard Deviation (SD) variations across rooms by user type.

		A	B	C	D	*F*
		M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	
MD	Computer Monitor	6.10 (1.03)	5.33 (1.69)	3.81 (2.39)	6.32 (.77)	14.91**
	Wall-mounted monitor	4.29 (3.04)	.39 (1.41)	5.03 (2.01)	4.93 (2.56)	28.78**
	Physician workstation	5.29 (2.04)	4.94 (1.87)	4.55 (1.86)	6.07 (1.04)	3.87
	Curtain	1.48 (2.13)	3.00 (2.87)	1.68 (2.27)	4.07 (2.65)	6.94**
MA	Computer Monitor	5.91 (1.28)	5.37 (2.11)	4.16 (2.41)	5.77 (1.57)	4.24*
	Wall-mounted monitor	4.05 (2.79)	1.00 (2.13)	3.60 (2.63)	3.59 (3.00)	5.35*
	Curtain	2.22 (2.61)	2.26 (2.88)	2.38 (2.84)	5.73 (1.67)	10.07**
Family	Sharing Info on Monitor	4.00(2.76)	2.20 (2.21)	5.50 (2.47)	3.75 (3.06)	5.73*
	Viewing Info. on Monitor	4.90 (2.57)	1.90 (1.74)	5.80 (2.38)	4.63 (2.77)	10.49**
	Wall-mounted monitor	5.68 (1.39)	.41 (1.53)	5.48 (2.40)	4.95 (2.48)	34.18**
	Curtain	2.23 (2.56)	3.73 (2.57)	2.64 (2.63)	4.45 (2.21)	3.50
	Exam Table	5.14 (2.38)	3.10 (1.87)	5.84 (1.70)	5.70 (2.05)	8.61**
Patient	Sharing Info on Monitor	4.15 (2.91)	1.50 (1.91)	5.75 (1.95)	4.53 (2.85)	7.84**
	Viewing Info. on Monitor	5.15 (2.64)	1.64 (1.98)	5.75 (1.95)	5.12 (2.71)	9.12**
	Computer Monitor	6.21 (.89)	3.29 (2.27)	5.63 (2.31)	5.82 (1.85)	6.72*
	Wall-mounted monitor	5.69 (1.89)	0	5.69 (2.15)	5.82 (2.30)	33.57**
	Curtain	2.29 (2.46)	4.07 (2.76)	3.06 (2.74)	5.00 (2.32)	3.28
	Physician workstation	3.21 (2.15)	4.57 (1.16)	4.38 (2.78)	5.94 (1.78)	4.53*
	Exam Table	6.14 (1.35)	4.14 (2.11)	5.81 (1.52)	6.41 (1.12)	6.35*

$p < .05$. *$p < .01$., **$p < .001$

Table 5.

Examples of open ended responses on liked or disliked exam room attributes.

Attribute	Location	Face-to-Face Communication	Information Sharing	Comfort and Safety	Impacting Flow
Computer monitor	Orientation of the computer to the patient and guest chairs was nice (RD; MD).	able to face patient while doing EMR (RB, MD).	the computer and monitor are still aimed at physician and not that easily shared (RB, MD).	I think wires hanging by the computers could be a problem (RA, Patient).	the ability to type and see the patient - lots of twisting back and forth (RB, MA).
Wall-mounted monitor	the direct spatial relationship between myself (patient) and physician and wall monitor (RA, Patient).	The discussion between patient and care giver hindered by the three large monitors and inability to look at the patient directly (RC, MA).	I liked the wall monitor/information sharing (RC, patient).	It was difficult to chart, as I had to look up to the wall monitor (RC, MD).	I do not like the monitor on the wall, hard for me to look and type (RC, MD).
MD workstation	Loved the setup of the table/computer in relation to the patient and guest (RA, MD).	The workstation did not allow for the MA or provider to see the patient (RB, MA).	I liked positioning of computer station with family and patient-easy to interview both and do documentation-show information on the screen (RA, MD).	Location of workstation was uncomfortable for me to view (RC, MD).	Flow (desk in the way), (RA, MD).
Exam table	chairs positioned well to be near physician while at computer (RB, MD).	I could face the patient and address both without having to turn around or have my back towards them (RC, MA).	I liked the opportunity for the patient to see multiple screens (RC, MA).	I did not like the window being where the patient was being examined or changing (RD, Patient).	With the exam table in the present orientation, only used 75% of the exam room's capacity (RA, MD).
Caregiver chair	the proximity (maybe too close almost) between the patient-physician-caregiver triangle (RA, Family).	viewing of patient and parent worked well (RA, MA).	could not really see the monitor on table or on wall, felt like as a parent tucked in the corner of the room (RD, Family).	everyone was very close and MD was very close to companions during exam (RD, MD).	The location of the side chairs. they seem in the way of the physician; tight on the set up in relation to exam chair and other chairs (RC, Family).

Table 6.
Total frequency of negative and positive open-ended comments based on room type and associated outcomes.

		Position	Flow	Patient Comfort	Gazing	Info Sharing	Staff Safety-Comfort
Total Frequency of Positive Comments	ROOM A	128	44	28	2	1	0
	ROOM B	102	9	32	40	9	6
	ROOM C	110	36	36	16	11	26
	ROOM D	94	30	42	6	3	12
Total Frequency of Negative Comments	ROOM A	128	44	28	2	1	0
	ROOM B	102	9	32	40	9	6
	ROOM C	110	36	36	16	11	26
	ROOM D	94	30	42	6	3	12

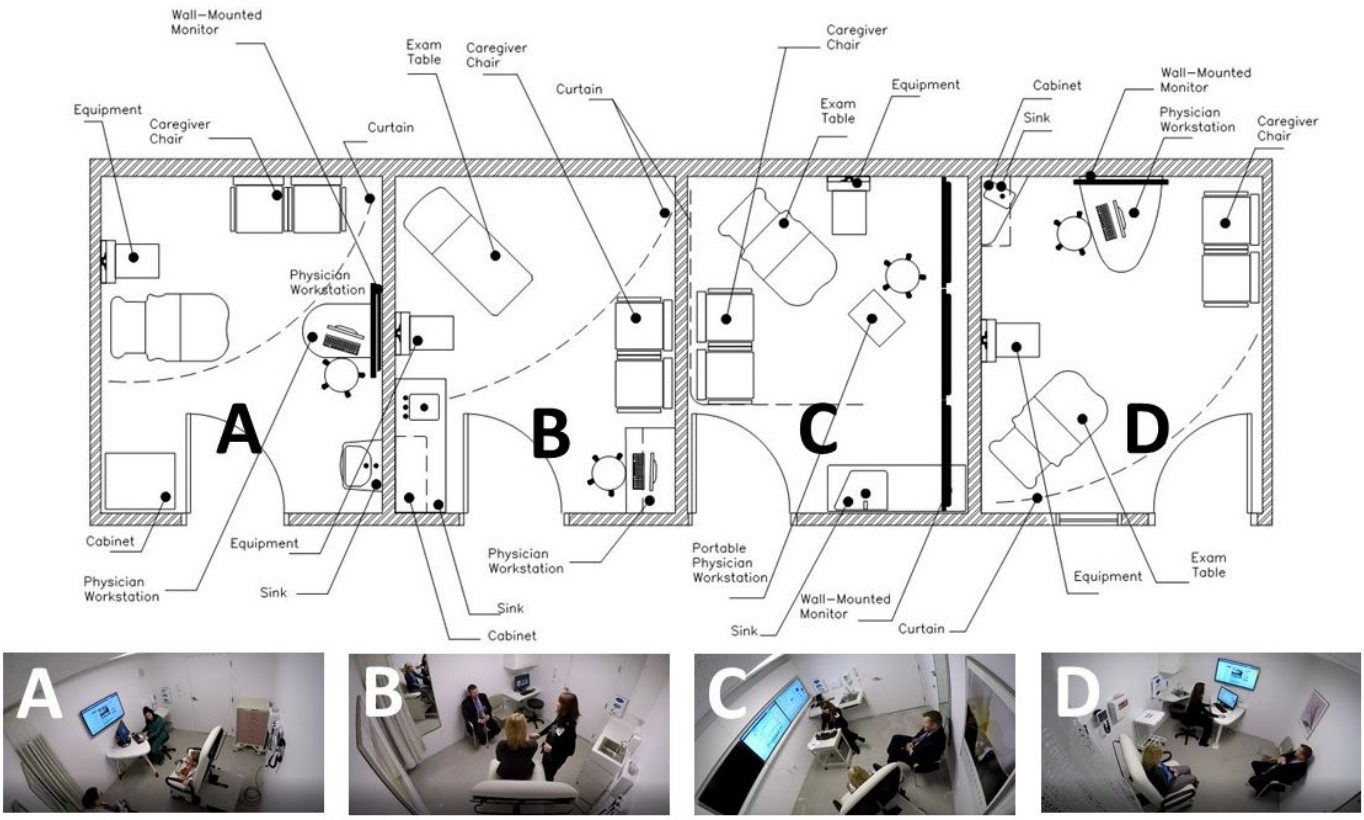

Figure 1. The four exam room layouts. Floor plans of full-scale mock-ups highlighting various physical features.

Image authorship: author.

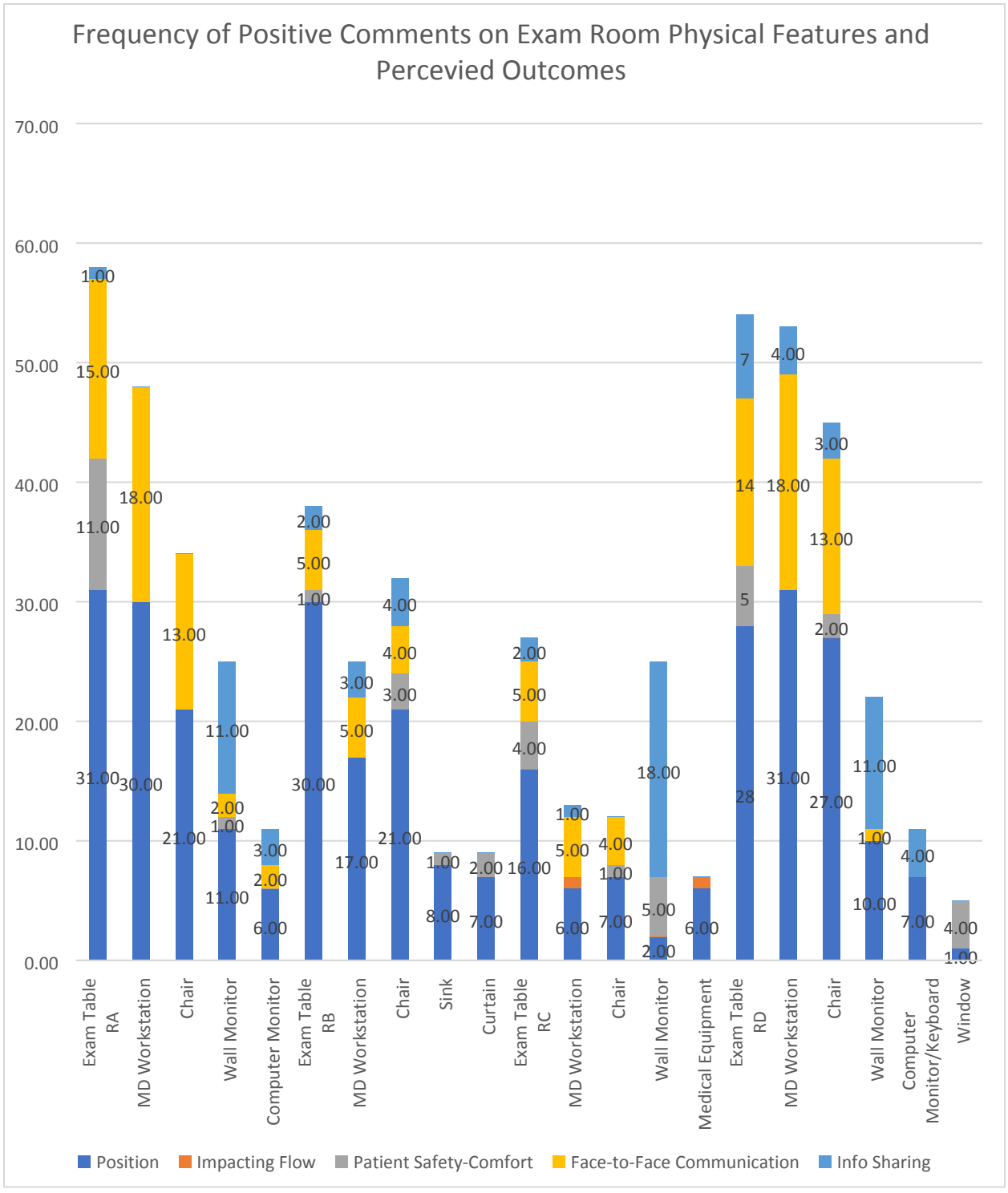

Figure 2. Open-ended comments content analysis results. The diagram displays frequency of positive comments on exam room features and associated outcomes. Image authorship: author.

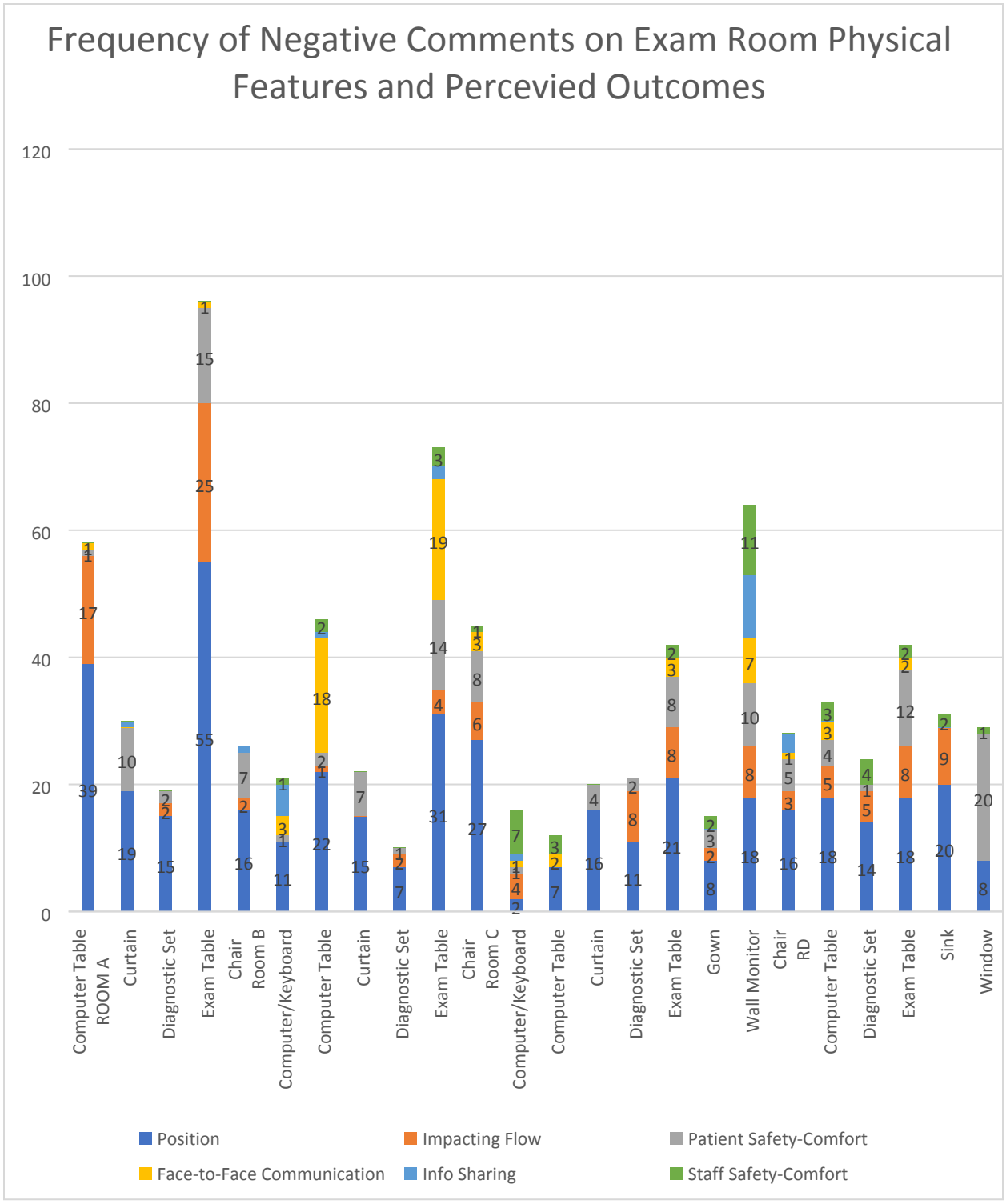

Figure 3. Open-ended comments content analysis results. The diagram displays frequency of negative comments on exam room features and associated outcomes. Image authorship: author.

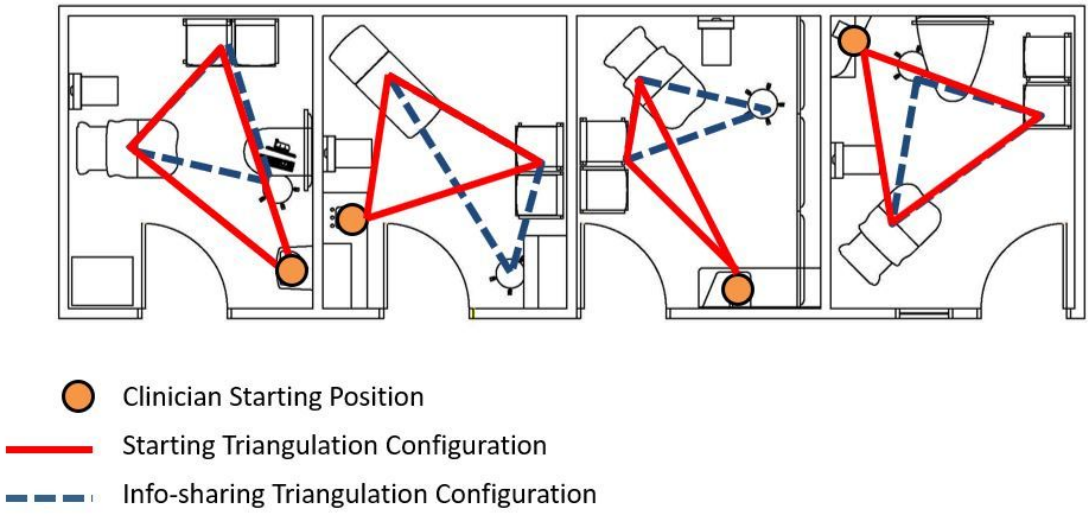

Figure 4. Triangulation diagram. This diagram shows the change in triangulation angles at start and information sharing stages of the exam visit. Image authorship: author.

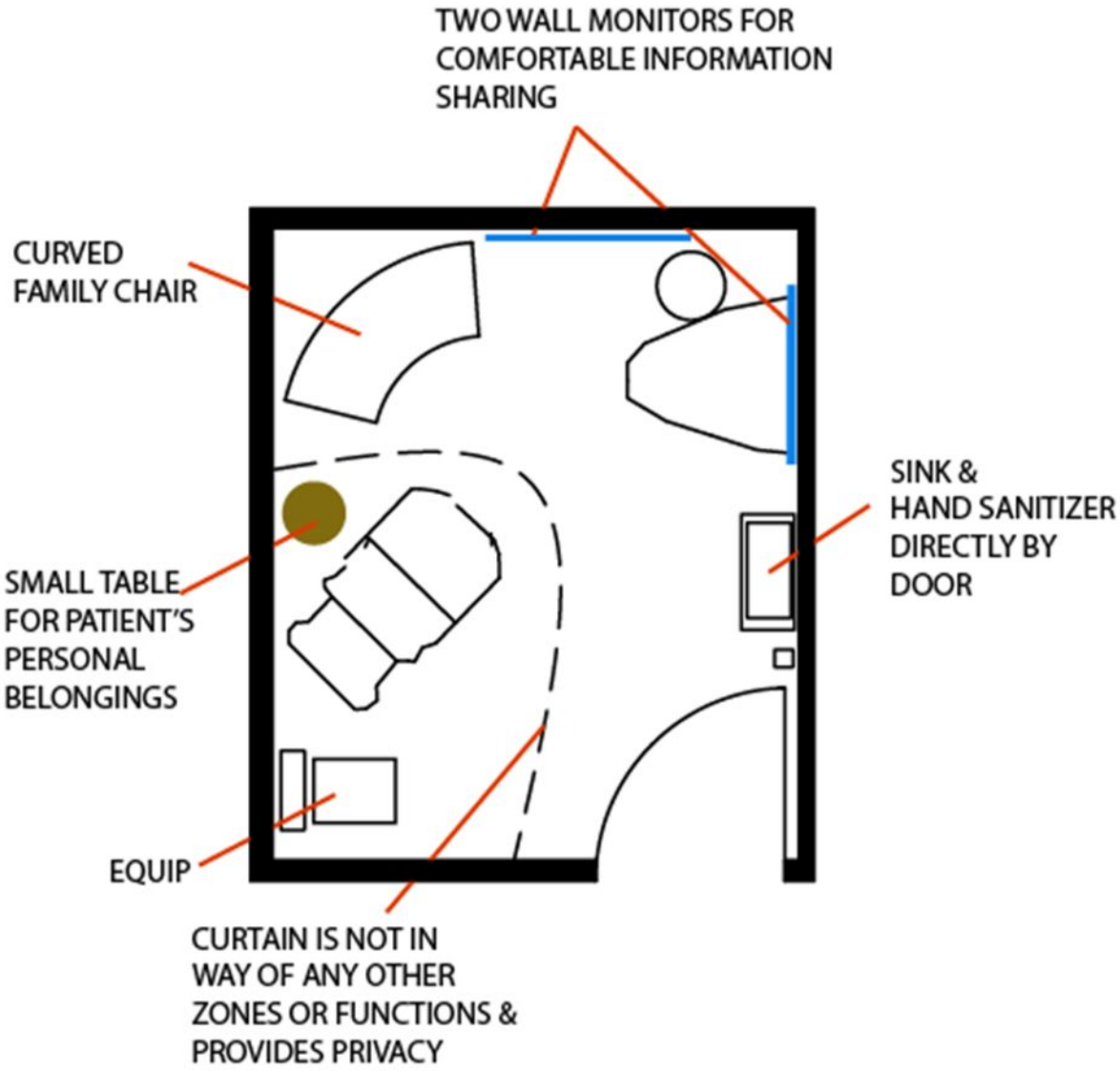

Figure 5. Ideal Exam Room Layout. This diagram displays a revised configuration of RD based on the empirical findings. Image authorship: author.

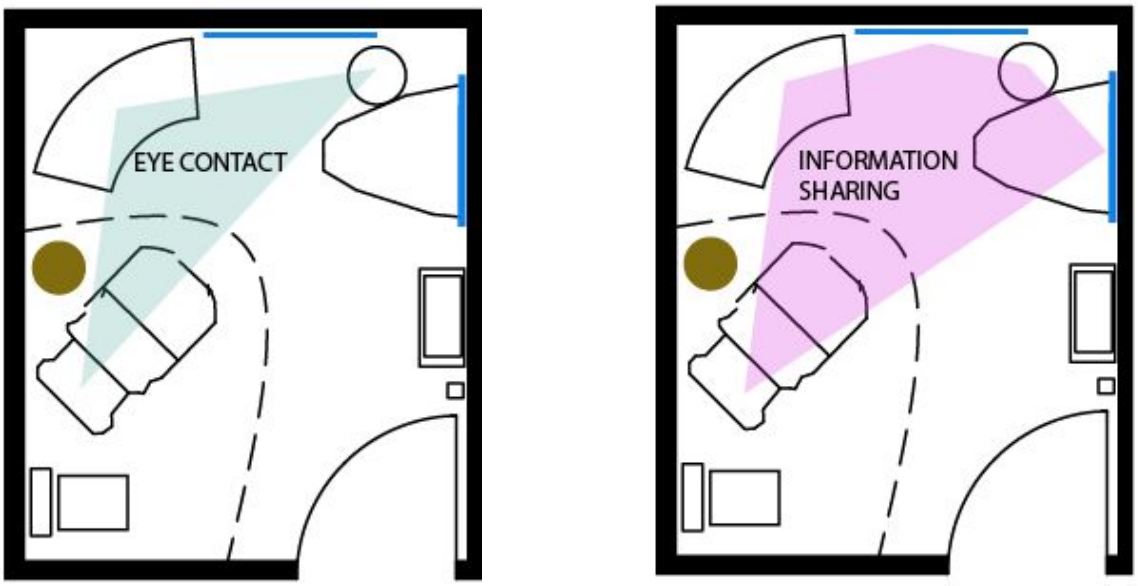

Figure 6. Ideal Exam Room Layout and triangulation. This diagram displays the revised configuration of RD clinical exam room that supports eye-contact and information-sharing by triangulating exam table, MD workstation, and family chairs, and wall-mounted monitor. Image authorship: author.

Implications for Practice

- Locate shared monitors directly in front of patients, caregivers, and physician to enhance information sharing, patient-family engagement, and comfort.
- Configure appropriate distance for room furniture positioning for comfortable maneuvering, comfortable access to equipment, and visibility of shared information.
- Triangular configuration of exam table, caregiver chairs, and physician workstation facilities eye contact, engagement, and productivity.
- Providers prefer semi-inclusive exam room configurations that include private and controllable computer screens on portable tables for comfortable information sharing, simultaneous data entry, and enhanced face-to-face communication.
- Exam table location, angle, and attributes is an essential factor for supporting patient privacy and comfort. Placing the exam table at the room corner with a 45 degrees angle and reasonable reach from provider chairs and curtain is preferable.

Executive Summary of Key Concepts

There is a growing focus on enhancing communication and information-sharing opportunities with integrated technologies in clinical exam rooms. However, the effects of the interactions between furniture and technology arrangements and attributes have not been adequately addressed. Converging different evidence, the current research evaluated the impacts of four different exam room configurations on patient-caregiver-clinician communication, EHR-interaction, and satisfaction. Results showed that semi-inclusive: physician-controlled configuration with triangular setup between MD workstation, exam table, and caregiver chairs were the most preferred and effective layout. This configuration supported comfortable information sharing, maintained patient privacy, promoted face-to-face communication and simultaneous data-entry. Favorable positioning of exam table and caregiver chairs happened when it supported screen-sharing on the wall-monitor and eye-contact with the provider. Patients and caregivers perceived to be "passive" users when rooms lacked features facilitating information sharing. The lack of personal computers for clinicians and constant body rotations to view screens was distracting, impeded patient privacy, and generated longer examination durations. Including multiple wall-mounted monitors was regarded as a positive distraction. However, users also preferred restricting the number of monitors to prevent overwhelming and distracting conditions for patients or clinicians. Adjustability and appropriate distances between furniture was an important consideration for achieving satisfactory evaluations.

SUPPLEMANTRY TABLES

Table 1.

Comparing room attributes and furniture.

Physical dimensions	**Room A**	**Room B**	**Room C**	**Room D**
Room Dimensions (LxW)	10’ x 12’	10’ x 12’	10’ x 12’	10’ x 12’
Exam table type	convertible	traditional	convertible	convertible
Exam table position	Left wall, perpendicular angle	Corner left, 45 degrees angle	Corner left, 45 degrees angle	Corner left besides the door, 45 degrees angle
Physician/consultation table	Movable, In middle of right wall, perpendicular angle, in front of patient, 90 degrees from caregiver chairs	Stationary, Parallel to right wall besides door, parallel to caregiver chairs	Movable on a small table with wireless keyboard	Stationary, In front of door, 45 degrees from exam chair, 90 degrees from caregiver chairs
Wall monitors	One above the consultation table	None	Three and in front of caregiver chairs, 45 degrees from exam tables	One above the consultation table
Distance between Exam table and monitor	6’ – 10 1/8”	10’ – 9 ½”	6’ – 3 11/16”	8’ – 6 7/8”
Caregiver chairs	In front of door, middle of back wall	Middle of Right wall	Middle of left wall	Corner of right wall
Sink (hand sanitizer, paper dispenser, etc.)	Corner of right wall, parallel and visible to door	Corner of left wall, parallel and behind the door	Corner of front wall, parallel and visible from the door	Corner of left - behind wall, parallel to door
Door	in middle, with storage space behind, in front of family chairs	in middle, sink and cabinet behind	at corner family chairs in front, sink adjacent	corner with chairs in front
Taxonomy	Semi-Inclusive clinician controlled	Exclusive	Inclusive	Semi-Inclusive clinician controlled

Table 2.
Average behavioral durations (aggregated data for talking, gazing, and EHR-interaction) per room type.

		BDS	BSS	TBS
Room Type	A	37.75 (28.79)	11.76 (9.50)	67.56 (49.02)
	B	39.75 (29.98)	11.65 (9.60)	69.56 (53.93)
	C	53.79 (36.43)	15.34 (11.52)	97.17 (73.41)
	D	37.55 (33.38)	10.68 (8.49)	74.32 (69.25)
Total		41.71 (32.58)	12.23 (9.85)	76.34 (61.90)

Table 3.

Average BDS durations of behaviors per examination stage across rooms.

	Room	Talking	Gazing	EHR-Interaction
BDS for MA Intake	A	56.05	43.91	17.94
	B	46.01	41.76	20.87
	C	55.23	29.58	91.13
	D	46.77	29.28	14.01
BDS for MD Infor Gathering	A	29.42	39.65	15.06
	B	35.86	47.48	22.86
	C	45.54	42.86	40.38
	D	34.85	32.20	19.50
BDS for MD Exam	A	56.57	28.54	NA
	B	60.72	43.64	NA
	C	75.22	59.77	NA
	D	53.31	24.34	NA
BDS for MD Diagnosis	A	54.73	45.49	24.00
	B	44.64	41.23	27.01
	C	69.20	55.05	30.69
	D	68.10	55.93	16.33

Table 4.

Average BDS and BSS durations of interaction behaviors (gazing and talking) across rooms.

		BSD	BSS
Room Type	A	43.72 (29.73)	13.98 (9.62)
	B	44.69 (31.61)	13.84 (9.73)
	C	54.11 (32.69)	17.84 (11.29)
	D	44.77 (35.28)	12.76 (8.17)
	Total	46.54 (32.36)	14.48 (9.80)

Table 5.
Descriptive results for actor versus non-actor participants.

	Survey Participants (actor and non-actor users)		Non-Actor Survey Participants	
	Frequency	Percent	Frequency	Percent
Physician	123	34.0	123	49.2
Medical Assistant	89	24.6	85	34.0
Adult Caregiver	54	14.9	0	0
Adult Patient	49	13.5	5	2.0
Pediatric Patient	12	3.3	5	2.0
Pediatric Family Member	35	9.7	32	12.8
Total	362	100.0	250	100.0

Table 6.
One-way ANOVA analysis on satisfaction with exam room features.

Satisfaction Rating	**RA Mean (*SD*)**	**RB Mean (*SD*)**	**RC Mean (*SD*)**	**RD Mean (*SD*)**	***F***
Monitor sharing	4.03 (2.83)	2.66 (2.5)	4.96 (2.47)	4.22 (2.86)	14.19***
Monitor information viewing	4.95 (2.6)	3.54 (2.7)	4.84 (2.44)	4.76 (2.68)	6.58***
Computer monitors	5.72 (1.61)	4.90 (2.13)	4.35 (2.59)	5.86 (1.49)	10.16***
Wall-mounted monitor	4.58 (2.7)	.63 (1.8)	4.81 (2.42)	4.71 (2.73)	76.48***
Exam table	4.83 (2.16)	4.30 (2.1)	5.61 (1.60)	5.65 (1.52)	12.13***
Physician workstation	4.48 (2.36)	4.50 (2.14)	4.31 (2.39)	5.60 (1.83)	6.61***

*** *p <.001*

Table 7.

Significant difference Satisfaction ratings of non-actor survey across rooms.

		A	B	C	D	F
		M (SD)				
MD	Computer Monitor	6.10 (1.03)	5.33 (1.69)	3.81 (2.39)	6.32 (0.77)	12.22**
	Wall-mounted monitor	4.29 (3.04)	0.39 (1.41)	5.03 (2.01)	4.93 (2.56)	24.38**
	Physician workstation	5.29 (2.04)	4.94 (1.87)	4.55 (1.86)	6.07 (1.04	3.75*
	Curtain	1.48 (2.13)	3.00 (2.87)	1.68 (2.27)	4.07 (2.65)	5.79**
MA	Computer Monitor	5.86 (1.28)	5.28 (2.14)	4.17 (2.46)	5.71 (1.59)	3.22*
	Wall-mounted monitor	3.90 (2.77)	1.06 (2.18)	3.75 (2.57)	3.43 (2.98)	3.4*
	Curtain	2.32 (2.63)	2.39 (2.91)	2.48 (2.86)	5.67 (1.68)	8.207**
	Linen Hamper	1.68 (2.30)	2.22 (2.98)	4.17 (2.84)	3.95 (2.61)	3.94*
	Exam Table	4.23 (2.29)	4.22 (1.99)	5.83 (1.50)	5.43 (1.25)	5.15**
Caregiver	Computer Monitor	5.75 (1.16)	3.43 (2.30)	6.10 (0.88)	6.00 (1.26)	5.65**
	Wall-mounted monitor	5.75 (1.16)	1.00 (2.65)	5.00 (2.79)	5.29 (2.50)	6.14**
	Physician workstation	5.50 (1.07)	3.29 (2.50)	4.56 (2.51)	6.57 (0.79)	3.77*

*p < .05. **p < .01.

Table 8.
Significant survey ratings between real and actor family members.

	Real	Actor	*F*
	M (*SD*)	*M* (*SD*)	
Computer monitor	5.39 (1.74)	4.21 (2.66)	4.89*
Curtain	2.46 (2.69)	3.63 (2.49)	4.21*
Diagnostic Set	4.70 (2.26)	3.10 (3.03)	6.58*

*p < .05. **p < .01.

Table 9.

Significant ratings of exam room features, within actor and real family participants.

		A	B	C	D	F
		M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	
Real	Computer monitor	5.75 (1.16)	3.43 (2.30)	6.10 (.88)	6.00 (1.26)	5.65**
	Curtain	2.38 (2.77)	1.86 (2.34)	1.70 (2.79)	4.29 (2.50)	1.52
	Diagnostic Set	4.75 (2.19)	5.29 (2.50)	5.00 (1.73)	3.71 (2.87)	0.62
Actor	Computer monitor	4.07 (2.67)	3.93 (2.43)	4.33 (3.33)	4.54 (2.30)	0.137
	Curtain	2.14 (2.54)	4.60 (2.23)	3.27 (2.40)	4.54 (2.15)	3.52*
	Diagnostic Set	3.62 (2.01)	2.60 (3.00)	3.13 (3.23)	3.15 (3.16)	.25

Table 10.
Significant differences between genders across all participants.

	Female	Male	*F*
	M (SD)	M (SD)	
Computer Monitor	5.34 (1.99)	4.75 (2.32)	6.30*
Chair	4.82 (2.57)	4.20 (2.82)	4.41*
Glove dispenser	4.68 (2.64)	3.87 (2.90)	6.89**
Diagnostic Set	4.25 (2.69)	3.60 (2.91)	4.37*
Soap dispenser	5.06 (2.50)	4.33 (2.82)	6.13*
Sink	5.18 (2.08)	4.69 (2.46)	3.905*