THE CLEMSON HEALTHCARE WORK SYSTEM ERGONOMIC ASSESSMENT TOOLKIT

A Macro-Ergonomic Evaluation for Ambulatory Workspaces

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I. OVERVIEW

Within the ambulatory care environment, healthcare organizations are challenged to address the rapidly advancing technological demands associated with electronic health records (EHR) when building new facilities or renovating existing infrastructures. *The Clemson Healthcare Work System Ergonomic Assessment Toolkit* is a tool for evaluating the ergonomics of alternative computer workstation configurations within the broader context of the ambulatory work system which they are placed. The toolkit provides guidance for analyzing the strengths and weaknesses of varying applications of technology integration into ambulatory workspaces to support evidence-based design decisions.

The Clemson Healthcare Work System Ergonomic Assessment Toolkit is an expanded ergonomic evaluation framework that was tested and refined through visits to five ambulatory surgery centers (ASCs). Twelve preoperative and postoperative rooms/bays with varying spatial configurations and types of workstations were evaluated and analyzed during the development of the toolkit. Although the toolkit was developed within the context of ASCs and their associated work flows, the toolkit can be utilized in other ambulatory workspaces where the impact of technology integration is crucial in supporting interactions between care providers, patients, and their care partners.

Who should use the toolkit?

The Clemson Healthcare Work System Ergonomic Assessment Toolkit is created to be used by those involved in healthcare facility design process and clinical end-users. Specifically, multidisciplinary design teams may find the toolkit helpful to support collaboration and provide insight into the trade-offs across multiple design solutions and the impact of computer workstation configuration within the broader work system.

When should the tool be used?

The Clemson Healthcare Work System Ergonomic Assessment toolkit can be used to assess ambulatory workspaces in a single facility, conduct a comparative analysis across multiple workspaces in a single facility, or to conduct a comparative analysis across several facilities.

- The toolkit can be used to conduct a post-occupancy evaluation of ambulatory workspaces in existing healthcare facilities.
- The toolkit can be used as a proactive design tool to assess and compare evolving design alternatives for new ambulatory workspaces.
- The toolkit can be used to support collaborative decision making between designers and clinical end-users.

What is required?

The toolkit has been developed to provide a holistic approach to evaluating and integrating computer workstations into ambulatory workspaces. While the components of the toolkit can be utilized separately to evaluate specific aspects of the design, it is recommended that the components be collectively utilized to provide a more comprehensive understanding of design alternatives.

As the toolkit can be used to facilitate a common understanding across multiple stakeholders of design implications associated with varying design solutions, it may be helpful to have a facilitator who can guide design discussions in relation to the findings generated from the toolkit.

II. WHAT'S IN THE TOOLKIT?

The Clemson Healthcare Work System Ergonomic Assessment Toolkit is divided into two sections:
Section 1: Documenting the existing conditions through components of the toolkit
Section 2: Analysis and synthesis of the data collected

Section 1 is organized into five components to support a holistic work system analysis through: 1) context and task analysis, 2) ergonomic assessment checklist, 3) photo protocol, 4) documentation of insights and challenges, and 5) physical assessment of space. Section 2 supports the analysis of findings through the visualization of zone spatial distribution and visibility from care team member to patient and their care partner for workspaces evaluated.

SECTION I

1.1. Context and task analysis

To conduct the task analysis, you will ask nurses to walk through and verbally describe the sequence of activities they would typically perform in their workspace. Emphases should be given to tasks that involved communication between care team members, patients, and their care partners and direct patient care activities, such as starting an IV and preparing the surgical site in preoperative workspaces, or administering necessary medications and explaining discharge instructions in postoperative workspaces. When conducting the task analysis, it essential that all care team members who utilize the workspace are equally considered. The goal of conducting this task analysis is to identify facilitators and barriers related to workstation functionality and usability within existing ambulatory workspaces or proposed design solutions for new workspaces. Figure 1 provides an example of the essential steps identified for various actors from a task analysis standpoint, which served as the foundation for understanding how their existing workspace either supported or inhibited their ability to deliver quality care. A semi-structured interview guide is provided in Component A to support conducting a task analysis.

ACTOR	TASK	ZONES				
		workstation	staff movement	care partner	support	supplies
Preop nurse *get patient prepared for surgery*	1. escort patient from waiting to pre-op bay/ room		■		■	
	2. take medical history	■				
	3. explain surgical process	■				
	4. start IV		■			
	5. prepare surgical site	■	■		■	■
	6. administer any necessary medications	■	■		■	
	7. monitor patient	■	■		■	
Anesthesiologist *ensure patient can undergo anesthetic induction and performs anesthetic induction*	1. verify medical history	■	■			
	2. verify surgical site	■	■		■	■
	3. explain anesthetic process	■	■		■	
	4. perform induction*	■	■		■	
	*this task is only performed at site 4					
Nurse anesthetist *transport and monitor patient during anesthetic induction*	1. verify if patient is ready for surgery		■			
	2. escort patient back to operating theater	■	■		■	
	3. monitor patient during procedure	■	■			
Surgeon *performs surgery*	1. answer last minute questions	■	■		■	
Care partner *individual who is supporting the patient*	1. wait with patient in pre-op		■	■	■	

Figure 1. *Essential steps of actors during care process within the workspace of an existing ASC*

1.2. Ergonomic assessment checklist

To evaluate the functionality and usability of the computer workstation to support care team practices, you will conduct and ergonomic assessment of the computer workstation. To develop the Clemson Healthcare Work System Ergonomic Assessment Checklist, an extensive literature review was conducted to identify the existing tools to evaluate workstations within a healthcare context. Of those identified, the Cornell Healthcare Computer Wall-Station Ergonomic Checklist was chosen as the base for developing the Clemson Healthcare Work System Ergonomic Assessment Checklist. The original 20 item checklist was expanded to include concepts such as visual and auditory connection between care team members, patients and their care partners and flooring attributes identified in the literature as enhancing staff work performance. The Clemson Healthcare Work System Ergonomic Assessment Checklist includes 28 questions requiring a "yes" or "no" response. Of those 28 questions, 16 are general to the computer workstation and its integration into the larger context of the work system, while 12 questions are specific to each usable configuration of the computer workstation. The ergonomic assessment check list can be used to evaluate various types of wall mounted computer workstations, computer workstations on wheels (WoWs), and boom mounted workstations. Figure 2 provides an example of an ergonomic assessment that was conducted in a postoperative workspace of an existing ASC. The checklist for conducting the ergonomic assessment is provided in Component B.

ERGONOMIC ASSESSMENT CHECKLIST | PRE OPERATIVE ROOM	yes	no
Is the height of the workstation adjustable?	✓	
Is seating provided for seated work?	✓	
For standing use, can the platform be easily raised to 48" from the floor?	✓	
For sitting use, can the platform be easily lowered to 25" from the floor?	✓	
Is there easy and independent adjustment of the monitor and keyboard adjustment?	✓	
Can the caregiver swivel and tilt the computer screen to a comfortable viewing position?	✓	
Does the design provide a horizontal surface for setting/signing a paper chart?	✓	
Do wrists or hands rest on sharp or hard edges while operating the keyboard?		X
Is the workstation positioned to provide timely access to central supplies?	✓	
Is the workstation positioned to provide timely access to medication?	✓	
Is the flooring material stable, firm and slip resistant?	✓	
Does the flooring material provide adequate support to reduce fatigue?	✓	
Is there adequate space around the workstation to perform patient care tasks?	✓	
Are electrical outlets accessible above 2 ft. from floor level?	✓	
Does the design have concealed and integrated cable management?		X
Are the surface finishes porous, smooth and easily cleanable?	✓	
Can the caregiver easily position the keyboard and screen to maintain visual contact with the patient?	✓	
Can the caregiver easily position the keyboard and screen to maintain visual contact with the care partner?	✓	
For standing use, are supplies accessible within a 73" vertical reach?	✓	
For standing use, are supplies accessible within a 29.7" horizontal reach?	✓	
For standing use, are vital monitors accessible within a 73" vertical reach?	✓	
For standing use, are vital monitors accessible within a 29.7" horizontal reach?	✓	
Is glare from ambient light reflected on the monitor?		X
Is glare from natural light reflected on the monitor?	N/A	
Is the workstation positioned to have a view of the outdoors without twisting of the head, neck, or torso?	N/A	
Is the workstation positioned to provide visual access to the central nursing station without twisting of the head, neck, or torso?	✓	
Is the workstation positioned to provide auditory access to the central nursing station?	✓	
If seated workstation is possible, is there space in the bay to accommodate height adjustable?	✓	

Figure 2. *Completed ergonomic assessment checklist from a postoperative workspace in an existing ASC*

1.3. Photo Protocol

While walking through the facility, you will capture a minimum of eight photographs to identify the various configurations within the work system and types of enclosure, as well as obtain a visual reference for the placement and orientation of equipment and supplies and aesthetic quality of the room. The images should capture all critical features within the ambulatory workspace. Component C provides a list of the minimum photos needed to support the ambulatory workspace evaluation. However, this is the minimum number of photos suggested. You will want to take as many photos as necessary to document the physical and aesthetic quality of the ambulatory workspace being evaluated.

1.4. Documentation of insights and challenges

Additionally, photos should be taken to document insights gathered during the evaluation that provide context to how and why specific features within the ambulatory workspace either support or inhibit interactions between care team members, patients, and their care partners, as well as direct patient care activities. It is also critical to capture spontaneous commentary from care team members to assist in documenting their perceptions of how effectively the computer workstation is integrated into their workspace to assist in annotating the images. Figure 3 provides an example of images from one preoperative workspace that were categorized and annotated to highlight the facilitators and barriers associated with integrating WoWs into an existing preoperative workspace.

Facilitators

Barriers

Figure 3. *Photo documentation of facilitators and barriers identified in the preoperative workspace of an existing ASC*

1.5. Physical assessment of space

To complete the physical assessment, you will want to sketch the essential components in plan, and possibly in section, for the ambulatory workspace being evaluated. The sketch should contain the location and identification of the standard features most generally found in the ambulatory workspace being evaluated, and will be utilized to assist in the analysis of zoning distribution and visibility graphs. Figure 4 provides an example of a sketch that was composed of a postoperative workspace from an existing ASC. Component D provides a checklist for the type of design features that should be incorporated into the sketch and their designated label, as well as graph paper for sketching the ambulatory workspace being evaluated. In the last section of Component D, you should note the physical constraints in the workspace observed during assessment.

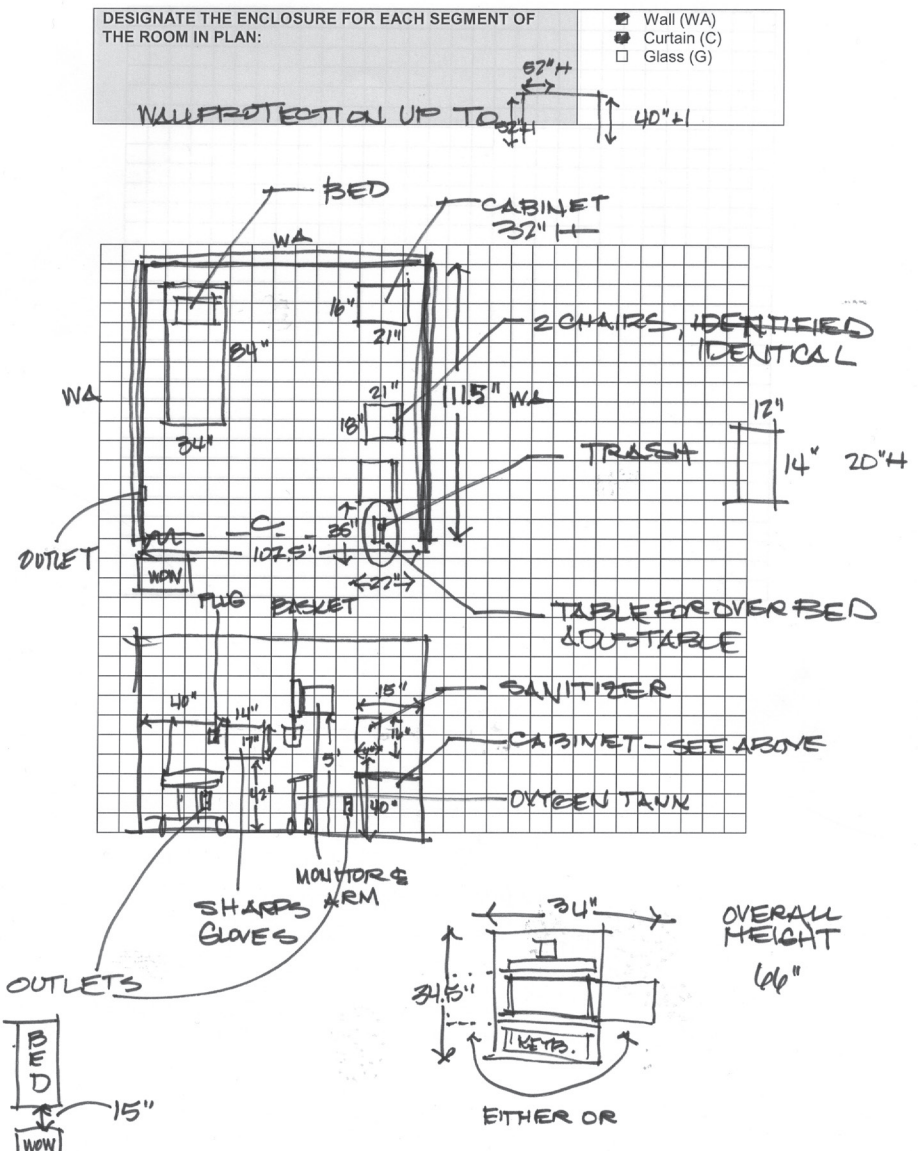

Figure 4. *Sketch of a postoperative workspace in an existing ASC in plan and section*

SECTION II

2.1. Development of zoning distribution plans

Utilizing findings from the task analysis and staff interviews, zoning distribution plans can be developed to provide insight into the functional constraints and affordances in the ambulatory workspace evaluated. Each workspace should be demarcated into five primary zones: staff, workstation, supply, care partner, and support. Once developed, the zoning distribution plans can be utilized to identify areas within the plan where access to necessary supplies, equipment, and care activities are either restricted or adequate space and zone adjacencies to perform optimally. If comparing multiple design alternatives or existing ambulatory workspaces, the zoning distribution plans will provide an opportunity to evaluate facilitators and barriers across environments. Figure 5 provides an example of a zoning distribution plan for a preoperative workspace from an existing ASC. The criteria for zone distribution can be found in Component E.

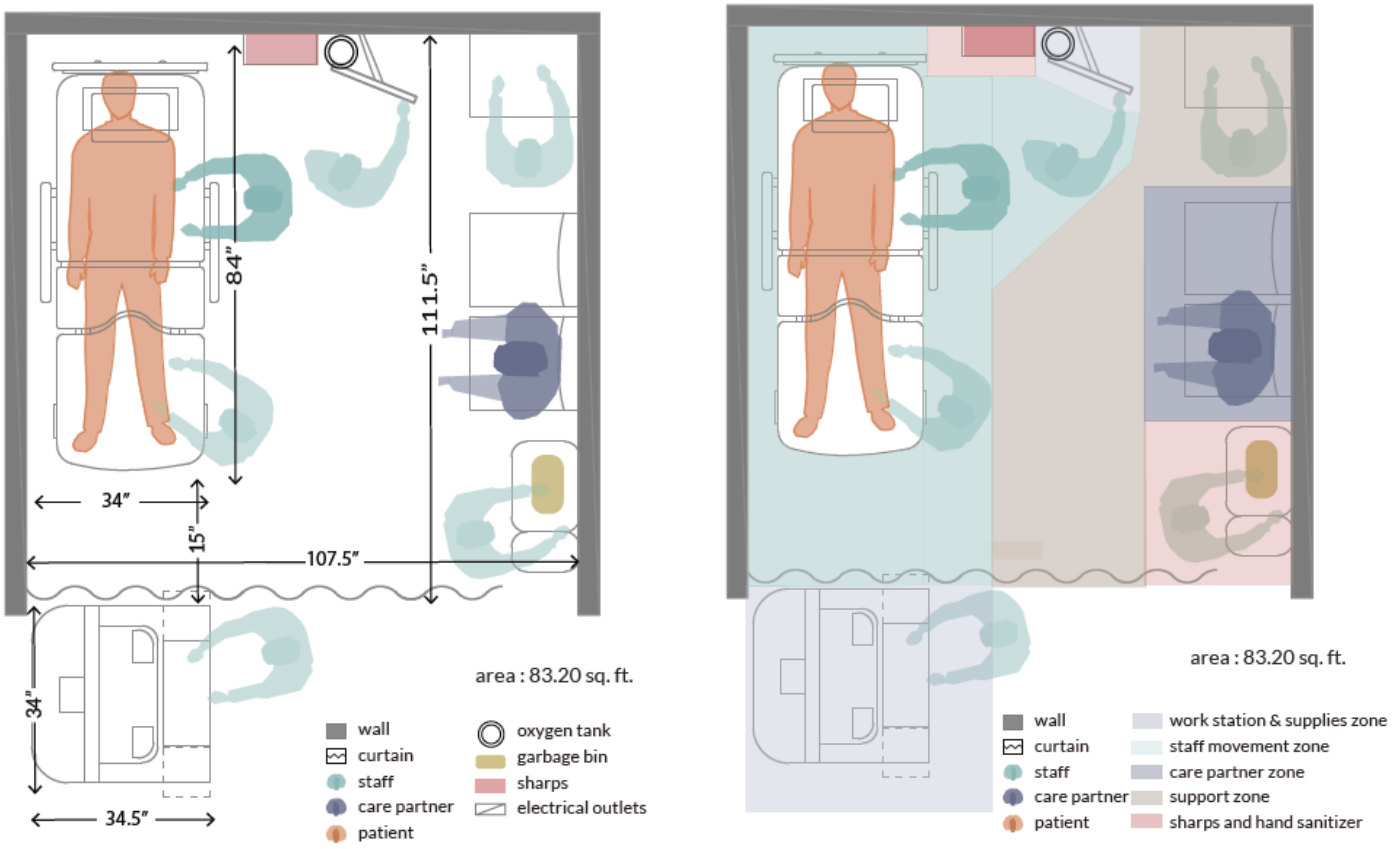

Figure 5. *Digital floor plans demarcated with zones*

2.2. Development of visibility plans

To provide insight into the potential impact of the computer workstation location within the work system on interactions between care team members, patients, and their care partners, visibility graphs can be constructed. Visibility graphs can be developed by demarcating on the plan the cone of vision from the care team member to both the patient and their care partner when in a standing and seated position at the computer workstation for the primary usable configuration. Once developed, the visibility plans can be utilized to identify computer workstation locations and configurations within the work system that could potentially require care team members to have a restricted or obstructed cone of vision to either the patient, care

partner, or both. Therefore, potentially inhibiting their interactions (e.g. for the care team member to enter information into the computer workstation, they must turn their back to the care partner). Figure 6 provides an example of a visibility plan from a preoperative workspace in an existing ASC. The evaluation criteria for visibility between care team members, patients and their care partners can be found in Component F.

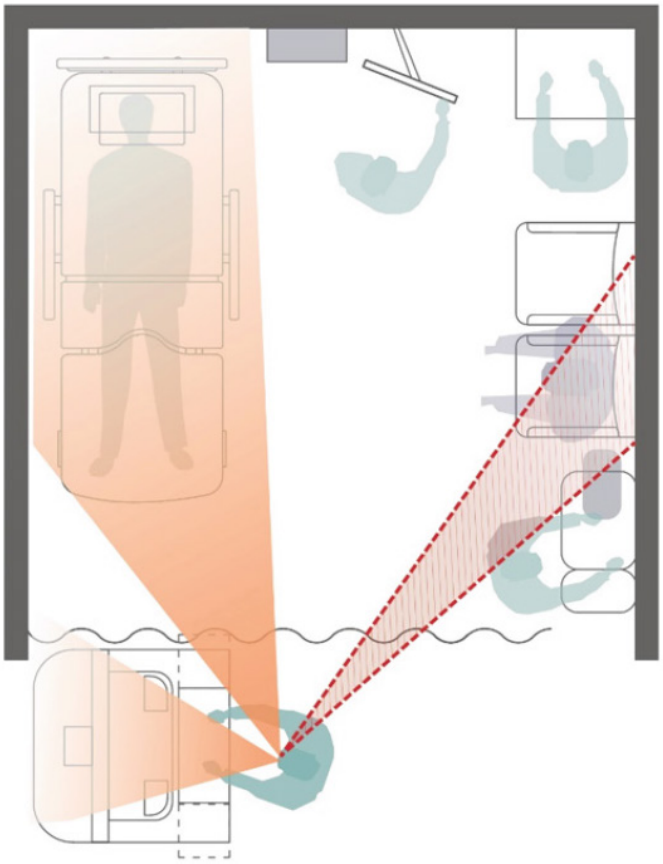

Figure 6. *Floor plans with cone of vision from care team member to care partner and patient in a preoperative workspace*

III. INSTRUCTIONS FOR USE OF TOOLKIT

The *Clemson Healthcare Work System Ergonomic Assessment Toolkit* can be used to evaluate the ergonomic quality of ambulatory work space design. Step by step instruction for how to use the components of the toolkit to conduct an ambulatory workspace evaluation are provided below, along with the reference to the coordinating appendices that support data collection and analysis strategies for the associated step.

SECTION I

1.1. Context and task analysis (Component A)

1. Map the sequence and type of tasks conducted within the workspaces according to each care team member type who utilizes the work space (e.g. nurse, surgeon, anesthesiologist, nurse anesthetist).
2. Conduct semi-structured interviews with each care team member following the task analysis in the workspace (Appendix A). The semi-structured interviews can be audio taped for further analysis, or notes can be taken during the interview to capture care team members perceptions of the workspaces being evaluated.

1.2. Assessment checklist (Component B)

1. Complete the checklist by observing the ambulatory workspace or spaces being evaluated, and responding to the questions in the checklist with a "yes" or "no". If the question does not apply, mark N/A.

1.3. Photo Protocol (Component C)

1. Take photos of all enclosures partitioning the space
2. Take photos of each usable computer workstation configuration
3. Take photos of any identified design challenges
4. Take photos of care team members preferred features or configurations within the work system

1.4. Documentation of insights and challenges (Component C)

1. Document notes regarding challenges identified by care team members and during observations
2. Document notes regarding insights gathered from care team members and during observations

1.5. Physical assessment of space (Component D)

1. Sketch the floor plan of each of workspace on graph paper and label the location of corresponding environmental features with designated letters to illustrate the layout of the space
2. Measure the width and depth of the work space size and dimension of outer edge of the workstation to edge of the patient bed.
3. Measure the distance from the outer edge of the workstation to edge of the patient bed.
4. Note the type of each enclosure surrounding the workspace .

SECTION II

2.1. Creating digital floor plans

1. Convert the on-site sketches of floor plans into scaled digital drawings using computer software.

2.2. Development of zoning distribution plans (Component E)

Mark the following five zones using different colors or textures onto the floor plan:

1. ***Staff movement zone:*** area around patient bed where direct patient care activities occur

   Demarcate a 1 ½ ft. area around all sides of the patient bed for the staff movement zone, designating the space required to comfortably support direct patient care activities from a standing position. Where a 1 ½ ft. area is not viable, the staff movement zone is occluded at the nearest enclosure, piece of equipment or furniture. Mark 3' from side and foot of the bed to the adjacent enclosure to determine the availability of adequate space around the bed.

2. ***Workstation zone***: area that encompasses the workstation and vital monitors
   Demarcate the computer workstation zone in plan based on the greatest extent to which any of the usable configurations could extend into the workspace.

3. Supply zone: area where direct patient care supplies, sharps and hand sanitizer are located
   Overlay the maximum square footage required to accommodate per manufacturer design specifications

4. Care partner zone: area where seating for the care partner is located
   Overlay the maximum square footage required to accommodate seating option per manufacturer design specifications.

5. Support zone: area that supports the movement of equipment and care team members
   Inlay the support zone into the remaining available space.

2.3. Development of visibility plans (Component F)

1. Mark the frontal cone of vision for the care team member from a standing and seated position
2. Mark the peripheral cone of vision for the care team member from a standing and seated position
3. Mark any restricted cones of vision for the care team member from a standing and seated position
4. Designate a different color or texture for the restricted cones of vision

2.4. Analyzing plans

1. Visually compare the zone distribution plans to understand the differences and similarities in the sizes of zones, location of computer workstations, adjacencies to other zones, and the extent to which the workstation zone intrudes into and fragments other zones within the work system.
2. Visually compare visibility graphs to understand configurations that inhibit or restrict visibility between care team member and staff and care partners.
3. Visually compare visibility graphs to identify configurations that support visibility to both patient and care partner simultaneously from either the frontal and/or peripheral position
4. Reflect on the potential impacts of these configurations based on design criteria developed from interviews and evaluation.

IV. ADDITIONAL RESOURCE

Wingler, D., Joseph, A., & Joshi, R. (2017, July). An Ergonomic Evaluation of Preoperative and Postoperative Workspaces in Ambulatory Surgery Centers. *In International Conference on Applied Human Factors and Ergonomics* (pp. 11-21). Springer, Cham.

V. TOOLKIT COMPONENTS

COMPONENT A

SEMI-STRUCTURED INTERVIEWS

A. Task Identification

A1. In your current role, what tasks do you most commonly perform during the patient care process?

A2. What changes in your current role do you anticipate due to changes in operational demands, policy changes, and/or new technologies?

A3. What aspects of your current role are likely to stay unchanged regardless of changes in operational demands, policy changes, and/or new technologies?

B. Quality of Care and Safety

B1. What do you think are the main quality of care and patient safety issues in your facility?

B2. How well do you think your facility is poised for supporting continuous quality care improvement?

C. Quality of Workspace

C1. Which areas in this facility do you consider as your workspace?

C2. Are there any instances in the past year when you feel your ability to deliver quality care was challenged or below par due to your workspace layout?

C3. Are there any instances in the past year when you feel your ability to deliver quality care was enhanced or above par due to your workspace layout?

C4. Are there any changes to your workspace (general design or specific features) that you feel would improve your ability to deliver quality of care?

C5. Are there any changes to your workspace (general design or specific features) that you feel would improve your physical and/or mental well-being during work hours?

C6. Are there any new technologies you would like to see integrated into your workspace that you feel would improve your ability to deliver quality of care?

C7. Are there any new technologies you would like to see integrated into your workspace that you feel would improve efficiency and effectiveness of your work flow or operations?

COMPONENT B
ERGONOMIC ASSESSMENT CHECKLIST

FACILITY

NAME:

LOCATION:

1. What area of the facility is the workstation in?	☐ Pre-op ☐ OR ☐ Post-op ☐ Induction Room
2. What type of workstation is it?	☐ Wall mounted ☐ Work on Wheels (WOW) ☐ Other
3. What tasks are commonly performed at this workstation?	
4. Are there ways in which you adjust the workstation to accommodate different tasks?	

FOR THE WORKSTATION	YES	NO
5. Is the workstation height adjustable?		
6. Is the seating provided for seated work?		
7. For standing use, can the platform be easily raised to 48" from the floor?		
8. For sitting use, can the platform be easily lowered to 25" from the floor?		
9. Is there easy and independent adjustment of the monitor and keyboard adjustment?		
10. Can the caregiver swivel and tilt the computer screen to a comfortable viewing position?		
11. Does the design provide a horizontal surface for setting/signing a paper chart?		
12. Do wrists or hands rest on sharp or hard edges while operating the keyboard?		
13. Is the workstation positioned to provide timely access to central supplies?		
14. Is the workstation positioned to provide timely access to medication?		
15. Is the flooring material in the workstation stable, firm, and slip resistant?		
16. Does the flooring material in the workstation provide adequate support to reduce foot fatigue?		
17. Is there adequate space around the workstation to perform patient care tasks?		
18. Are the electrical outlets accessible above 2 ft from floor level?		

COMPONENT B *contd.*

ERGONOMIC ASSESSMENT CHECKLIST

FOR THE WORKSTATION	YES	NO
19. Does the design have concealed and integrated cable management?		
20. Are the surface finishes porous, smooth and easily cleanable?		

FOR EACH USABLE CONFIGURATION	YES	NO
21. Can the caregiver easily position the keyboard and screen to maintain visual contact with the patient?		
22. Can the caregiver easily position the keyboard and screen to maintain visual contact with the care partner?		
23. For standing use, are supplies accessible within a 73" vertical reach?		
24. For standing use, are supplies accessible within a 29.7" horizontal reach?		
25. For standing use, are vital monitors accessible within a 73" vertical reach?		
26. For standing use, are vital monitors accessible within a 29.7" horizontal reach?		
27. Is glare from ambient light reflected on the monitor?		
28. Is glare from natural light reflected on the monitor?		
29. Is the workstation positioned to have a view of the outdoors without twisting of the head, neck, or torso?		
30. Is the workstation positioned to provide visual access to the central nursing station without twisting of the head, neck, or torso?		
31. Is the workstation positioned to provide auditory access to the central nursing station?		
32. If seated workstation is possible, is there space in the bay to accommodate height adjustable?		

COMPONENT C

PHOTO PROTOCOL

PHOTO PROTOCOL	YES	N/A
Wall 1		
Wall 2		
Wall 3		
Wall 4		
Usable configuration 1		
Usable configuration 2		
Usable configuration 3		
Design challenges		

ADDITIONAL COMMENTS OR INSIGHTS

DESIGN CHALLENGES

COMPONENT D

PHYSICAL ASSESSMENT OF SPACE

SKETCH AND LABEL WITH DESIGNATED LETTER IN PLAN THE LOCATION OF:	YES	N/A
Workstation (W)		
Bed (B)		
Care Partner seating (CP)		
Monitors (M)		
Supplies (S)		
Bedside table (BT)		
Window (WI)		
Gas outlets (GO)		
Trashcan (T)		
Electrical outlet (EO)		
Gloves (G)		
Other (O)		

MEASURE THE FOLLOWING AND LABEL IN PLAN

- ☐ Width of the room/bay
- ☐ Depth of the room/bay
- ☐ Outer edge of workstation to the edge of patient bed

DESIGNATE THE ENCLOSURE FOR EACH SEGMENT OF THE ROOM IN PLAN

- ☐ Wall (WA)
- ☐ Curtain (C)
- ☐ Glass (G)

OBSERVED PHYSICAL CONSTRAINTS

COMPONENT D *contd.*

PHYSICAL ASSESSMENT OF SPACE

COMPONENT E
CRITERIA FOR ZONE DISTRIBUTION

ZONE	CRITERA FOR EVALUATION
WORKSTATION ZONE	Easy access to supplies for direct patient care activities; visibility to both patient and care partner simultaneously from the most commonly used configuration; space optimization; ease of physical access to patient
STAFF MOVEMENT ZONE	Ability to access patient from all sides; accessibility to direct patient care supplies
CARE PARTNER ZONE	Visibility to patient and staff simultaneously; not in the direct path of staff travel patterns
SUPPORT ZONE	Unobstructed space to accommodate the circulation of multiple care team members; unobstructed space to accommodate the flow of additional equipment
SUPPLY ZONE	Co-location of direct patient care supplies; accessibility of sharps to direct patient care activities; accessibility visibility of hand sanitizer to care team members

COMPONENT F
CRITERIA FOR CONE OF VISION

CONE OF VISION	CRITERA FOR EVALUATION
FRONTAL CONE OF VISION	Line of sight when care team member is looking directly in front of them at a 0% angle
PERIPHERAL CONE OF VISION	Line of sight when care team member is looking in a 45% angle or less in either direction from a frontal position
RESTRICTED CONE OF VISION	Line of sight when care member is looking beyond a 45% angle in either direction from a frontal position

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