Human Factors Engineering in Healthcare: Provider Well-Being and Patient Safety

Priyadarshini Pennathur, PhD

Industrial, Manufacturing and Systems Engineering

University of Texas at El Paso

prpennathur2@utep.edu

Introduction

Human factors engineering applies the science of human capabilities and limitations to healthcare system design. It aims to enhance safety, efficiency, and satisfaction for both patients and healthcare providers.

This approach is critical in healthcare settings where complex technologies, workflows, and environments can create opportunities for error if not properly designed with human users in mind.

Key Areas in Healthcare Human Factors

1

Physical Environment Design

Creating spaces that promote safety, reduce fatigue, and enhance workflow efficiency in clinical settings.

2

Medical Device Usability

Ensuring equipment interfaces are intuitive, minimize cognitive load, and prevent user errors.

3

Clinical Workflow Optimization

Analyzing and redesigning processes to eliminate inefficiencies and error-prone steps.

4

Information Display

Organizing data presentation to support quick comprehension and decision-making.

Human Factors Methods in Healthcare

Observational Studies

Watching healthcare professionals in their natural work environment to identify challenges and opportunities for improvement.

Usability Testing

Evaluating how effectively users can interact with medical devices or systems to accomplish tasks.

Heuristic Evaluations

Systematic inspection of interfaces against established usability principles to identify potential problems.

Simulation

Creating realistic scenarios to test systems or train staff without patient risk.

Stairwell Use in Hospitals: Research Overview

Health Benefits

Stair use improves fitness, body composition, and cardiovascular health.

Cost-Effective Activity

Requires no special equipment, changing clothes, or membership fees.

Workplace Integration

Can be easily incorporated into daily work routines.

Design Improvement Opportunity

Architectural changes can encourage more consistent stair use.

Study: Design Implications to Increase Stairwell Use

Research Approach

Case study at a teaching hospital examining why staff choose elevators over stairs. Online survey collected data from hospital staff and students.

Key Findings

Travel distance and direction were primary reasons for preferring elevators. Staff would climb up to four floors but preferred elevators beyond that threshold.

Design Recommendations

Motivational signs, cardio indicators, progressive stair numbering, and artistic enhancements could encourage stairwell use.

Why Staff Choose Elevators

Hands Full

Staff carrying equipment, supplies, or documents find doors difficult to open.

Patient Transport

Moving patients between floors necessitates elevator use.

Physical Limitations

Staff with knee problems, arthritis, or injuries find stairs painful after long shifts.

Environmental Issues

Poor maintenance, cleanliness concerns, and uncomfortable temperatures deter use.

Top Design Recommendations for Stairwells

Cardio indicators

Display calories burned by climbing stairs to motivate health-conscious staff.

Progressive stair numbering

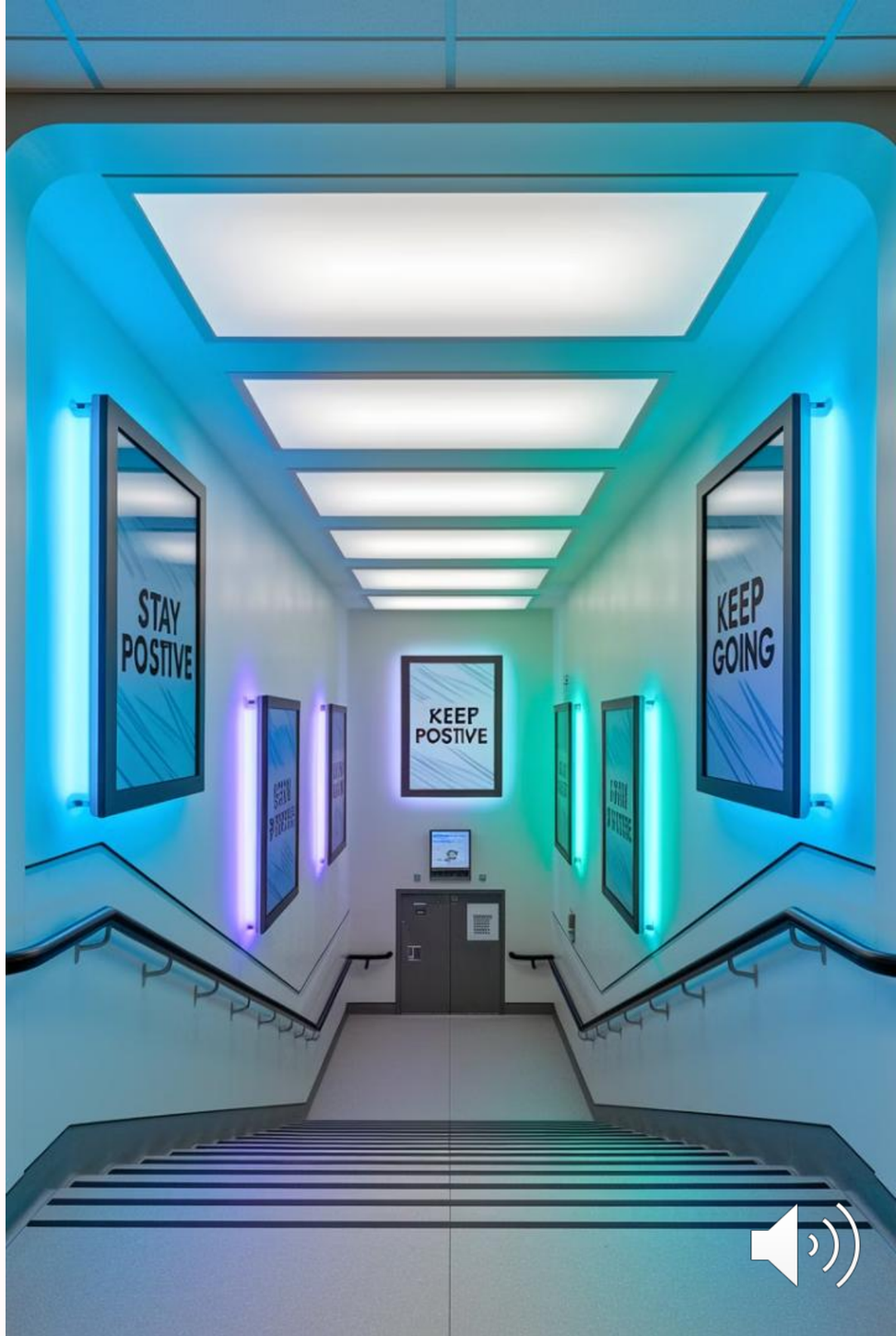
Show cumulative stairs climbed to create a sense of achievement.

Motivational signage

Place encouraging messages at decision points to influence behavior.

Creative lighting and aesthetics

Enhance visual appeal with better illumination and artistic elements.



Physical Stairwell Improvements

Door Redesign

Easier-to-open doors for staff carrying items. Consider foot-operated options.

Regular Maintenance

Ensure stairwells are clean, well-lit, and properly maintained to address safety concerns.

Windows

Add natural light through windows with outside views where architecturally possible.

Wider Stairwells

Design for comfortable passing of two people on stairs, not just at landings.

Smart Infusion Pumps: Research Overview

Safety Critical

Complex devices with high-stakes consequences for medication delivery.

Error Potential

Between 2005-2009, 56,000 infusion errors occurred in the US, resulting in 710 deaths.

Design Challenges

Despite safety features, usability problems persist in both hardware and software.

Research Need

Human factors evaluation necessary to identify and address design weaknesses.

Study: Usability of Smart Infusion Pumps

Research Approach

Combined observational data with heuristic evaluation to identify usability problems in a common smart pump model.

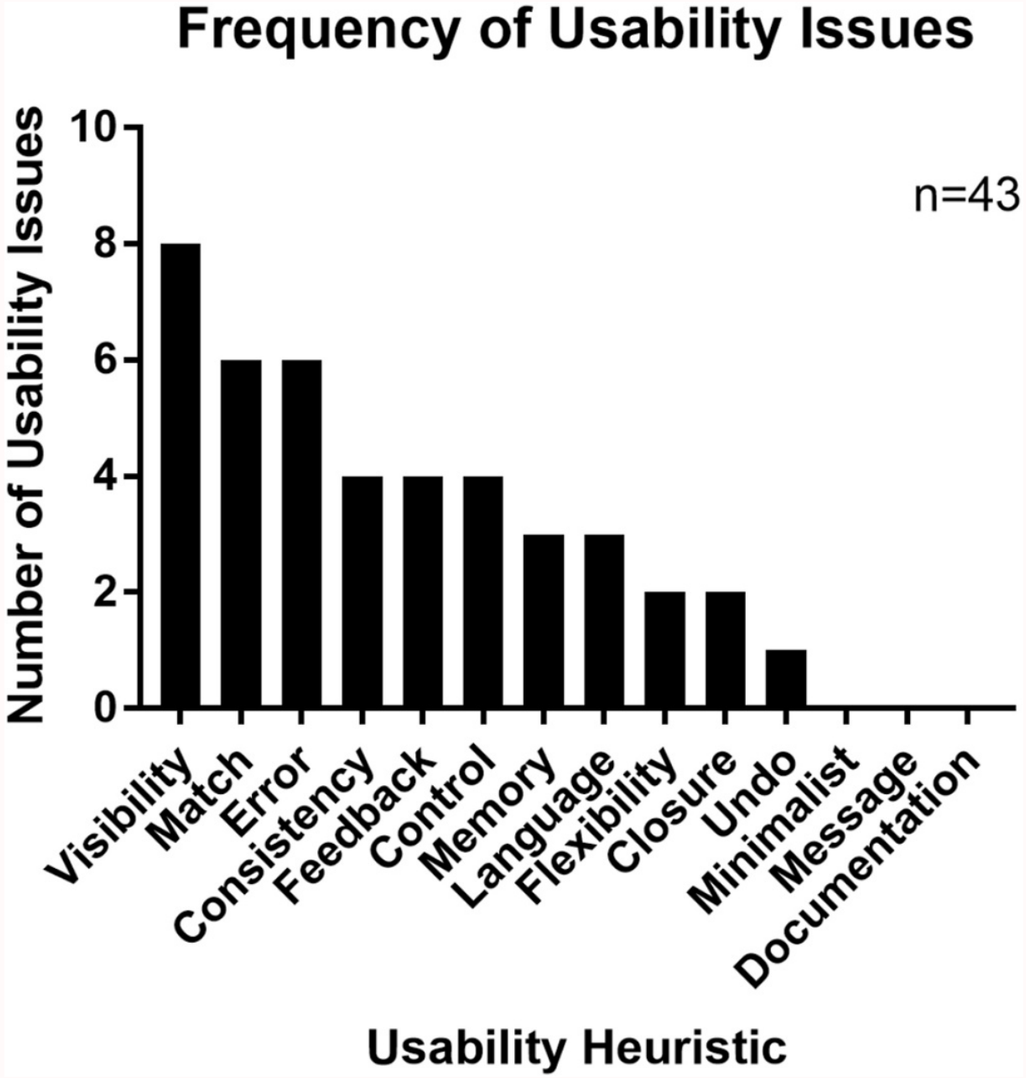
Setting

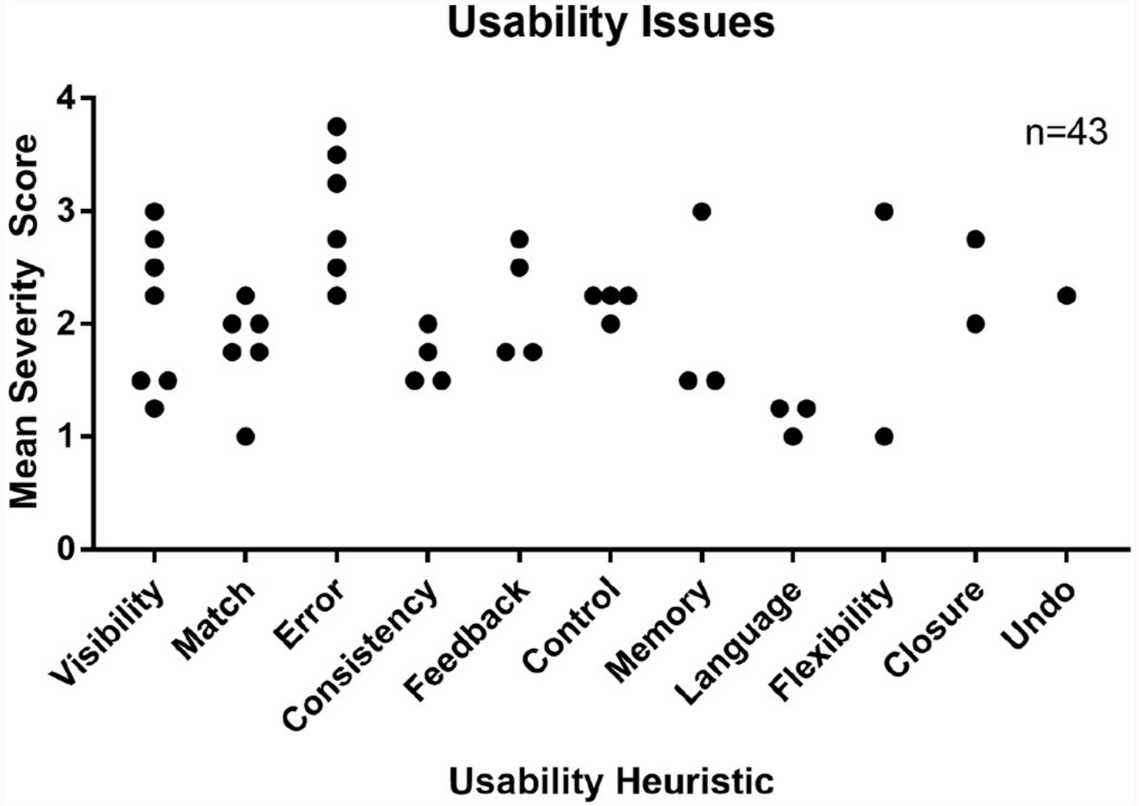
Two intensive care units at a Midwest quaternary academic medical center. Observed 10 nurses using smart pumps with secondary medication administration.

Method

Researchers used established heuristic criteria for medical devices while observing nurse interactions with pumps in real clinical settings.

Major Usability Issues Identified





The study identified 43 unique usability problems with smart pumps. System visibility, real-world match, and error prevention were the most frequently violated usability heuristics.

Smart Pump Design and Use Challenges

Tubing Matrix Organization

Nurses struggled with untangling multiple IV lines before setup. Some managed nine infusion bags simultaneously with no organizational mechanism.

Physical Maneuvering

Awkward positioning of IV hooks and controls. Personal protective equipment added complexity to interactions.

Interface Interaction

Software interface offered minimal guidance for troubleshooting. Unclear error messages required additional staff assistance.

Drip Chamber Verification

Nurses rarely observed drip chambers after unclamping despite protocol requirements, revealing misunderstanding of pump capabilities.

Environmental Impact on Smart Pump Use

Crowding

Multiple staff, family members, and clinicians in patient rooms created distractions during pump setup.

Room Layout

Suboptimal placement of pumps relative to computers and supplies increased walking distance and workflow interruptions.

Noise

Constant background noise from conversations, equipment, and alarms disrupted concentration during critical tasks.

Alarms

Both helpful and problematic alerts required nurse attention, sometimes with unclear resolution pathways.

Roller Clamp Issues

High-Severity Problem

1

Leaving roller clamps closed on secondary tubing was identified as catastrophic, preventing medication delivery without clear notification.

Inconsistent Practices

2

Some units routinely use clamps while others avoid them completely, creating risk during patient transfers between units.

Workarounds

3

Nurses developed techniques like holding tubing below pump's center of gravity to prime lines without using clamps.

No Detection System

4

Smart pumps lack capability to detect closed clamps or alert users effectively about flow status.

Most Critical Design Problems

Inconspicuous Warnings

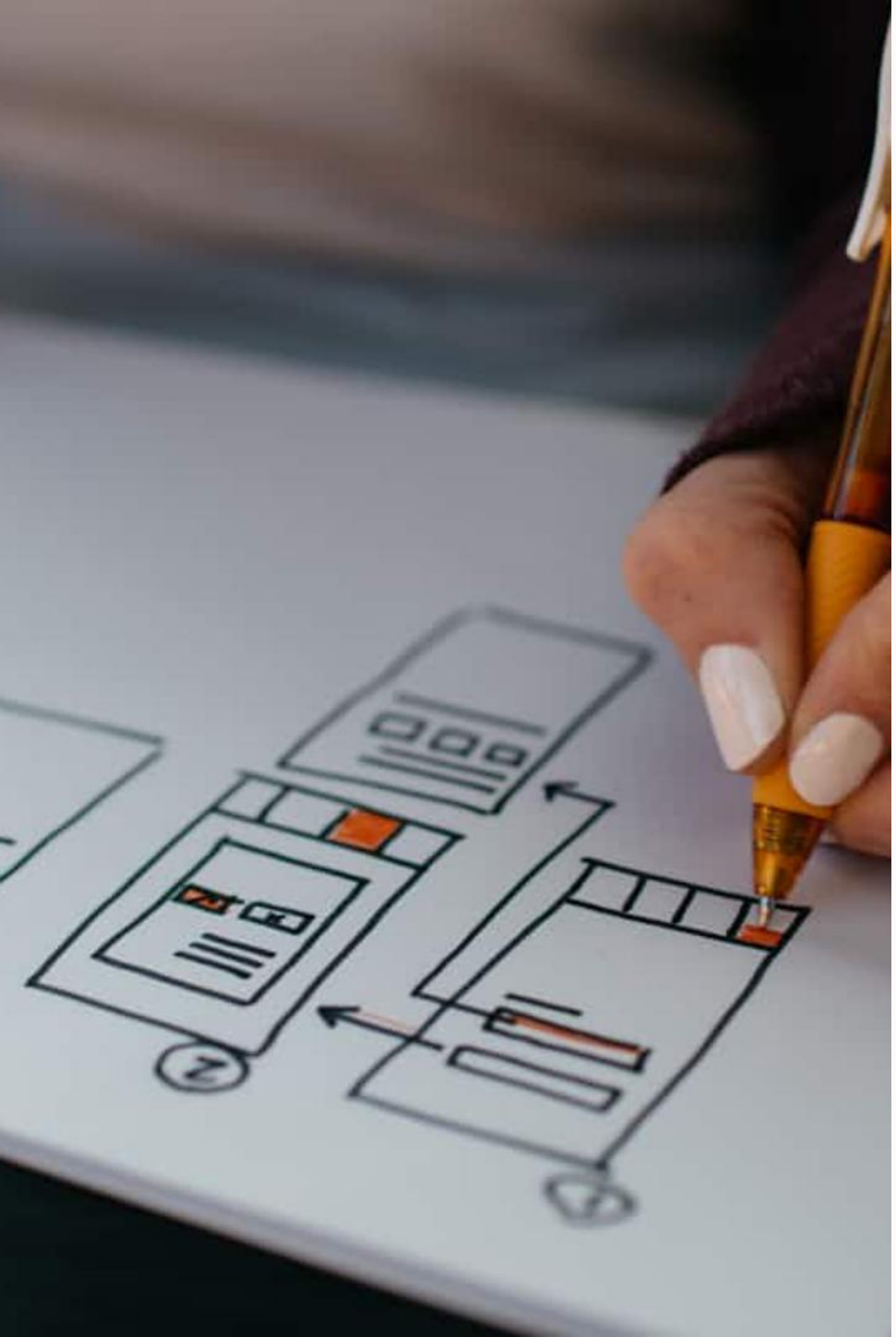
Critical messages about checking drip chambers and opening roller clamps were easy to overlook on the interface.

Missing Flow Sensors

No mechanism to detect if fluid was actually flowing through secondary tubing after programming.

Flow Status Ambiguity

Difficult to determine whether primary or secondary fluid was currently infusing without visual confirmation.



Recommended Smart Pump Design Improvements

Flow Sensors

Integrate sensors to confirm fluid movement in secondary tubing

Redesigned Clamps

LED indicators showing open/closed status

Visual Interface

Clear representation of fluid flow and system status

Tubing Organization

Mechanisms to prevent tangling and simplify management

Process Redesign

Change step sequence to eliminate critical errors

Proposed Interface Improvements

Visual System Mapping

Clear visual representation of the physical infusion setup to improve system understanding.

Prominent Warnings

Enhanced visibility of critical alerts, particularly for roller clamp status issues.

Fluid Status Indicators

Visual representation of IV bag fluid levels during medication delivery.

Active Channel Display

Clear indication of which channel is currently delivering medication.

Intuitive Interaction

Redesigned interface elements to simplify nurse interactions in clinical settings.

Proposed interface designs incorporate visual mapping of the physical setup, clearer warnings, and better representation of system status to reduce cognitive burden.

Environmental and Procedural Recommendations

Sterile Cockpit Approach

Designate no-interruption zones around pumps during programming with visual markers on the floor.

Standardized Training

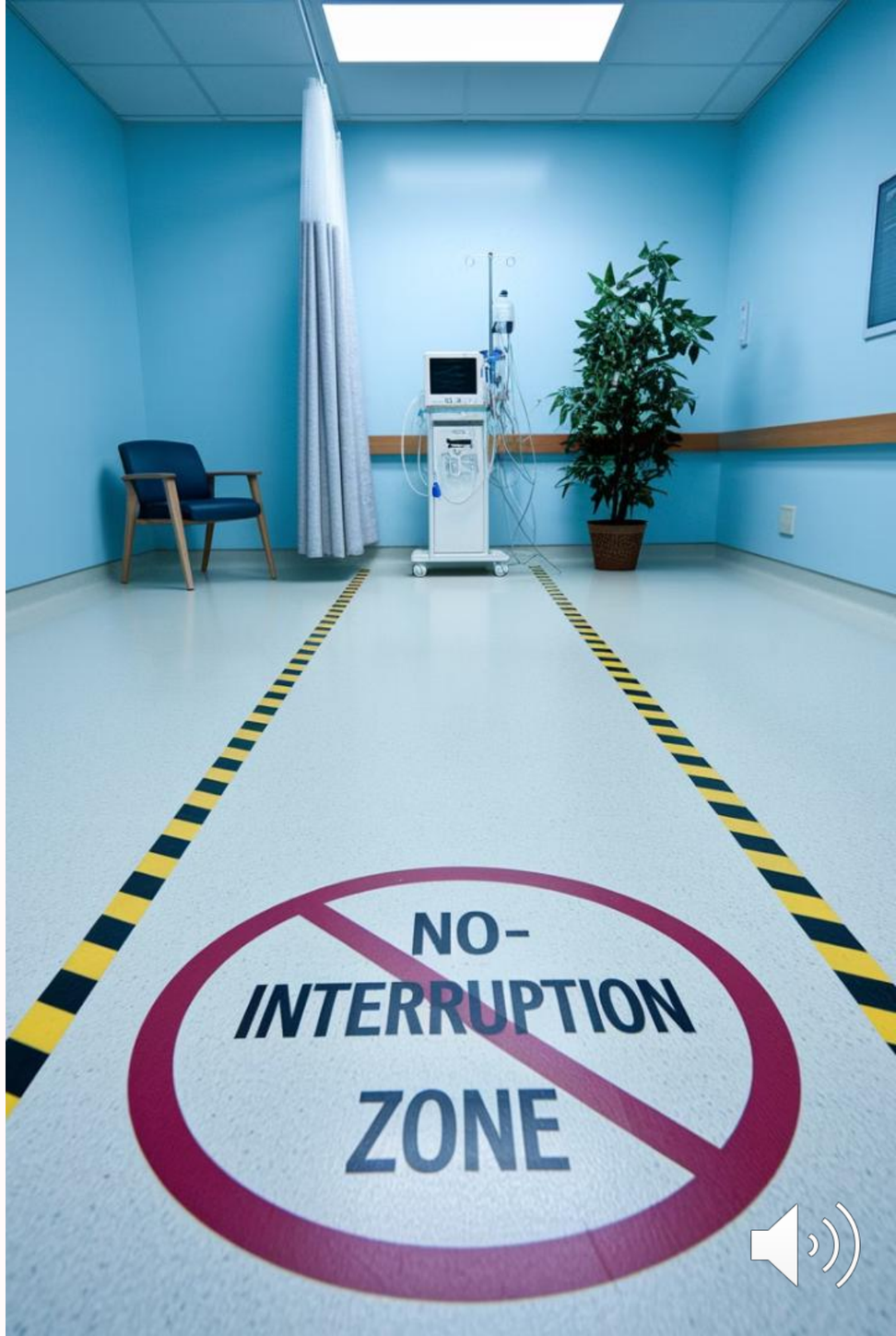
Ensure consistent procedures across all units, particularly for roller clamp usage.

Workstation Positioning

Optimize placement of pumps relative to computers and supplies to minimize walking and disruptions.

Education for Staff and Families

Provide clear guidance about not interrupting during medication administration.



Implications for Human Factors Research

1

Combine Methods

Integrating observations with heuristic evaluations provides richer understanding of medical device usage.

2

Study Real Environments

Context matters—laboratory evaluations miss critical environmental factors affecting device use.

3

Include Multiple Perspectives

Engineers and clinicians bring complementary insights to usability evaluations.

4

Test Before Implementation

Iterative design improvements require evaluation before clinical deployment.

Future Directions in Healthcare Human Factors

1

AI Integration

Exploring how artificial intelligence can enhance user interfaces while maintaining human oversight.

2

Remote Healthcare

Adapting human factors principles to telemedicine and home-based care technologies.

3

Wearable Technology

Applying human factors to design of wearable medical devices for monitoring and treatment.

4

Safety Culture

Developing organizational approaches that support human factors implementation.

5

Cross-Disciplinary Collaboration

Strengthening partnerships between engineers, designers, clinicians, and patients.

Thank you and References

Smart Infusion Pump Study

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Hospital Stairwell Research

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Contact: prpennathur2@utep.edu