From Fatigue to Flow: The Role of Human Factors Engineering in Nursing in High-Intensity Settings

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ABSTRACT

Human Factors Engineering (HFE) is a multidisciplinary science that examines how humans interact with systems, tools, and environments. In healthcare, its application is transformative: by designing...

Human Factors Engineering (HFE) is a multidisciplinary science that examines how humans interact with systems, tools, and environments. In healthcare, its application is transformative: by designing processes that align with human strengths and limitations, HFE reduces medical errors and enables clinicians to deliver safer, more effective care.

This is particularly relevant in high-intensity nursing environments such as bone marrow transplant units and apheresis services, where nurses balance advanced technology, clinical judgment, and compassionate patient care. These procedures often last several hours, requiring sustained attention, technical proficiency, and emotional resilience. Within such demanding contexts, nurses face cognitive overload, frequent interruptions, and physical fatigue. HFE offers strategies to shift this experience from exhaustion to “flow” a state of focused efficiency and professional satisfaction ultimately improving both patient outcomes and staff well-being.

Understanding Human Factors Engineering in Healthcare

HFE does not attempt to change the individual nurse; instead, it redesigns systems to fit human capabilities. As Carayon et al. (2014) emphasize, the goal is to create safer, more intuitive environments that minimize error and support critical thinking. In nursing, this translates into reducing physical strain, cognitive overload, and communication failures factors strongly linked to burnout and patient harm.

For apheresis nurses, whose work depends on both technology and direct patient interaction, HFE principles are especially valuable. Bone marrow transplant nurses likewise operate in environments where precision, vigilance, and teamwork are paramount. In both settings, human factors design can transform workflows into safer, more sustainable practices.

Human Factors Challenges in Apheresis and Transplant Nursing

High-stakes procedures such as stem cell collection, plasma exchange, and therapeutic leukapheresis demand continuous coordination between nurses, machines, and patients. Common challenges include:

- **Complex machine interfaces:** Variability between models, unclear alarm systems, and non-intuitive controls increase cognitive load.
- **Environmental ergonomics:** Poor lighting, cramped spaces, or awkward workstation design contribute to musculoskeletal strain.
- **Workflow interruptions:** Calls, alarms, or staffing shortages divert attention during critical procedures.
- **Documentation burden:** Dual paper and digital systems create redundancy and consume valuable time.
- **Cognitive fatigue:** Nurses must simultaneously process machine data, patient needs, and environmental cues, leading to mental exhaustion.

These challenges highlight the need for system-level redesign rather than expecting nurses to simply “work harder.”

Applying Human Factors Engineering Principles

Ergonomic Design

Optimizing the physical workspace reduces fatigue and strain. Adjustable chairs, height-appropriate monitors, and organized supply layouts minimize unnecessary movement. Proper lighting and noise reduction enhance concentration. Research confirms that ergonomic improvements increase both performance and job satisfaction.

Equipment Usability

In high-intensity settings such as bone marrow transplant and apheresis units, equipment usability is critical to both patient safety and nurse performance. Devices must be designed with **usability engineering principles** that prioritize intuitive controls, consistent interfaces, and clear alarm hierarchies. Whether operating stem cell collection systems, infusion pumps, or apheresis machines, nurses benefit from standardized layouts and predictable functions that reduce cognitive load.

Color-coded tubing and connectors help minimize setup errors across different devices, while tiered alarm systems enable staff to distinguish between urgent and routine alerts, ensuring timely and appropriate responses. Importantly, involving nurses in **usability testing and evaluation** before equipment adoption ensures that technology aligns with real-world workflows and clinical demands. This participatory approach not only reduces the risk of error but also enhances efficiency, confidence, and satisfaction among nursing staff (Gurses & Pronovost, 2011).

Standardization and Cognitive Aids

Checklists, visual flowcharts, and color-coded trays reduce variation and cognitive effort. These tools allow nurses to focus on patient assessment rather than repetitive tasks. Standardization also minimizes omissions and supports consistent practice across teams.

Workflow and Communication

Structured communication formats such as SBAR (Situation, Background, Assessment, Recommendation) improve handoffs and continuity. Pre-shift huddles align team priorities and identify risks. Assigning a “float” nurse to manage calls or supplies prevents interruptions, allowing primary nurses to maintain focus.

Fatigue Management and Staffing Design

Fatigue is a predictable human response to sustained demand, not a personal weakness. HFE emphasizes workload balance and recovery opportunities. Protected breaks during long procedures, equitable distribution of high-intensity tasks, and adequate rest between shifts improve alertness and morale (Scott et al., 2019).

Simulation and Continuous Learning

Simulation-based education allows nurses to practice troubleshooting rare complications or emergencies in a safe environment. Team debriefings focus on process improvement rather than blame. Interdisciplinary simulations foster collaboration among nurses, physicians, and engineers, strengthening system resilience and safety culture.

From Fatigue to Flow: The Impact of Human Factors Design

When HFE principles are applied, the transformation is tangible. One center reported a **25%**

reduction in nurse-reported fatigue and fewer equipment-related incidents after implementing ergonomic layouts, standardized checklists, and pre-shift huddles. Nurses described feeling more “in flow”— focused, efficient, and less mentally taxed.

This reflects the broader goal of HFE: to create systems that help people succeed rather than relying on perfection. When processes align with human behavior, nurses perform with greater precision and confidence, and patients receive safer, more consistent care.

Challenges and Future Directions

Despite clear benefits, barriers remain. Many healthcare organizations still view human error as an individual failing rather than a system design issue. Limited funding for ergonomic redesigns and lack of HFE training among leaders hinder progress.

Moving forward, institutions should:

- Integrate human factors concepts into nursing education and leadership development.
- Encourage collaboration between nurses, engineers, and quality teams.
- Use digital quality management tools to analyze trends, identify weak points, and guide redesign.

Embedding HFE into continuous quality improvement ensures that safety initiatives address root causes rather than symptoms.

Conclusion

Human Factors Engineering provides a transformative lens for improving nursing in high-intensity settings such as bone marrow transplant and apheresis. By redesigning systems around human strengths and limitations, healthcare organizations can reduce fatigue, improve safety, and enhance workflow.

For nurses, applying HFE means fewer errors, smoother processes, and more time for meaningful patient connection. Achieving “flow” in this context is not about working harder, it is about designing smarter systems that empower nurses to deliver safe, efficient, and compassionate care.

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