

Wayfinding as a Patient-Centered Safety System: A Human Factors Case Study of Escalator Use and Fall Risk in Healthcare

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Abstract

Falls are a persistent patient safety concern throughout healthcare facilities, yet prevention efforts often focus on monitored clinical settings rather than the complex environments patients navigate before and after outpatient care. This case study examines escalator use and fall risk in a large academic medical center through a human factors assessment of wayfinding, signage, and environmental design. The objective was to identify opportunities to reduce unsafe navigation decisions by improving access to safer vertical transport options. A human factors safety engineer conducted an observational environmental audit across interconnected buildings, parking structures, and patient access pathways. The assessment qualitatively evaluated sign visibility, decision points, route complexity, and anticipated user behavior. Findings indicate that escalators were frequently more visible and convenient than elevators, while elevator routes were less prominent, inconsistently labeled, and often located along less intuitive pathways. These conditions contribute to navigation uncertainty and may increase reliance on higher-risk options, particularly for individuals with mobility limitations, fatigue, or unfamiliarity with the facility. Proposed interventions include enhancing the visibility and timing of elevator signage, incorporating destination-confirmation cues, implementing progressive wayfinding systems, and reinforcing navigation guidance through patient-facing workflows. This study demonstrates that wayfinding should be treated as a patient-centered safety system. Applying human factors principles to the design of healthcare navigation can improve decision-making, reduce preventable risk, and enhance the overall patient experience in complex care environments.

Keywords

Patient Safety, Systems Engineering, Healthcare Design, Hospital Navigation, Built Environment

1. Introduction

Patients visit hospitals and medical centers for preventive care, diagnosis, and treatment. Healthcare organizations have a responsibility to support safety throughout each visit, including safe navigation through complex built environments. Fall prevention is one important patient safety goal. In healthcare organizations, falls are a prevalent and complex problem that can result in serious injury or death. One study found that falls can increase hospital length of stay by 6 days and cost hospitals an average of \$13,000 more per patient (Wong et al. 2011). Protocols are in place to assess fall risk once patients are checked in for an appointment or admitted to the hospital, with extensive fall risk mitigation strategies in inpatient settings and during outpatient encounters (Morris et al. 2022). However, fall risks may also occur before and after outpatient encounters, when patients and visitors are often outside direct staff monitoring or assistance. These risks can be challenging to quantify and address (Abujudeh et al. 2014). Therefore, the built environment must support safe navigation for patients and visitors throughout healthcare facilities.

At an academic medical center in the Midwestern United States, escalator-related falls were identified as a potentially preventable safety risk. In one study of outpatient falls, escalator-related incidents represented 10% of reported outpatient falls (Abujudeh et al. 2014). Following two safety incidents, the patient safety team at this academic medical center noted particular concern for patients with mobility limitations, fluctuating health status, or unfamiliarity with the facility. The organization requested an assessment by the Human Factors Safety Engineer.

1.1 Objectives

The objective of this work was to identify opportunities for improved escalator safety for patients and visitors navigating the academic medical center.

The study aimed to:

1. Identify and characterize wayfinding barriers that may contribute to unsafe escalator use and fall risk.
2. Evaluate the effectiveness of existing signage systems in guiding users to elevators.
3. Develop human-centered signage and wayfinding interventions.

2. Literature Review

Wayfinding involves decision-making while navigating architectural features and environmental cues. These tasks are more burdensome in complex and unfamiliar environments. Arthur and Passini (1992) integrated architecture, signage, and human cognition to create a wayfinding model that coordinates environmental and informational cues through intentional signage strategies. Kwon et al. (2025) used eye-tracking methods to assess spatial cognition for wayfinding and found that users often fixate on incorrect environmental features and miss signage cues. These studies highlight the importance of designing healthcare spaces as integrated systems rather than isolated architectural components.

In healthcare settings, Devlin (2014) demonstrated that poor wayfinding systems contribute to stress, confusion, and inefficiencies for patients and visitors, reinforcing the need for intuitive environmental design. Design-focused literature also emphasizes that effective wayfinding requires coordinated visual communication systems; Calori and Vanden-Eynden (2015) describe how consistent, strategically placed signage systems function as an integrated component of the built environment rather than standalone elements.

In human factors, Norman (2013) introduces principles such as affordances and visibility to explain how people interact with systems and environments. Norman's work emphasizes intuitive design and the mitigation of user error, both of which are important heuristics for healthcare wayfinding. The SEIPS model provides a systems-based human factors framework linking environment, tasks, technology, and outcomes (Carayon et al. 2006). It positions the built environment as a critical determinant of patient safety and workflow efficiency. This framework is essential for integrating wayfinding into broader safety systems.

Although literature on fall risk in hospitals often focuses on hospitalized patients (Heinzmann et al. 2025; Morris et al. 2022; Randell et al. 2021), it emphasizes the importance of environmental design considerations as part of safety strategies. Xing et al. (2020) identified key behavioral risk factors for escalator-related injuries, including instability, distraction, and failure to hold handrails. Their findings indicate that older adults and users who are multitasking are at increased risk, supporting the need for clear cues and simplified environments.

Literature integrating wayfinding, architectural design, and mobility-related risk in healthcare environments remains limited. This case study describes an environmental behavior assessment grounded in human factors methods to support the design of targeted safety interventions.

3. Methods

This study was conducted through an observational environmental audit of an academic medical center in the central United States. One human factors expert conducted the observation, which included route tracking and assessment of anticipated and observed behavioral interactions. The assessment was intended to identify and characterize environmental conditions that may contribute to navigation challenges rather than to provide quantitative measures of navigation performance.

This observation included an assessment of:

- Sign visibility

- Decision points
- Path complexity

The observation was followed by human-centered design recommendations. Because this was a single-site observational case study, findings are intended to inform local improvement and generate transferable design considerations rather than provide generalizable estimates for safety risk.

4. Data Collection

Several sources were used to complete this observational case study. The human factors expert worked with the patient safety team to gather information from incident reports of escalator-related falls, including limited details about outpatient destinations and patient experiences. Observational data included route choices and environmental documentation, including photos and signage. Three key variable types were recorded:

- Navigation choices (escalator vs. elevator)
- Anticipated wayfinding errors, such as wrong turns or hesitation
- Visibility and comprehension of signage

5. Results and Discussion

5.1 Observational Case Study Results

The academic medical center has five patient and visitor parking structures and three main entrances with connected parking garages, valet parking, and patient drop-off areas. Several buildings are connected, allowing visitors to enter through one entrance and navigate across campus to their destination. This navigation often requires vertical movement using stairs, escalators, or elevators. This case study focuses on three connected buildings, one adjacent parking garage, and three pairs of escalators. Green Parking serves as patient and visitor parking for the cancer center (Building 1), the outpatient center (Building 2), and the main hospital tower (Building 3). Parking connects to the main floor of Building 2. To travel from Building 1 to Building 2, patients and visitors must move up one floor by escalator or elevator. Between Buildings 2 and 3, patients and visitors can cross on most floors; however, a primary pathway to the cafeteria requires traveling up two floors. One elevator and two pairs of escalators are available between Buildings 2 and 3.

In Buildings 1 and 2, escalators are often more visible and convenient than elevators, potentially increasing the risk of inappropriate escalator use. Combined with gaps in signage clarity, visibility, and destination confirmation, this design may contribute to navigation uncertainty and unsafe path choices. Current signage and wayfinding systems do not adequately differentiate safer navigation routes, such as elevators, from higher-risk options, such as escalators. Existing signage also lacks sufficient destination confirmation and continuity cues. Patients may choose escalators because of proximity and visibility, uncertainty about elevator location, or the perceived inconvenience or distance of elevator routes. These conditions may increase fall risk and reduce the quality of the patient experience.

To translate observational findings into actionable improvements, identified wayfinding barriers were mapped to human factors-informed interventions (Table 1). This approach supports the development of targeted environmental and operational changes intended to improve navigation clarity, reduce uncertainty, and encourage safer route selection.

Table 1. Identified Wayfinding Barriers and Proposed Human Factors Interventions

Identified Barrier	Human Factors Implication	Potential Safety Impact	Proposed Intervention
Elevators are less visible than adjacent escalators at key decision points.	Users tend to choose the most visible and immediately available option.	Increased use of escalators by individuals who may be better served by elevators.	Add prominent elevator signs before decision points and improve line-of-sight visibility to elevators.
Elevator signage lacks destination-confirmation information.	Users may be uncertain whether the elevator provides access to their intended destination.	Patients may default to escalators because the route appears clearer.	Add destination-specific messaging on elevator signs (e.g., Pharmacy, Green Parking, Cancer Center, Main Hospital).

Elevator routes require navigation through long hallways with limited visual cues.	Increased physical and cognitive workload and uncertainty during navigation.	Wrong turns, hesitation, prolonged navigation, and reliance on more visible escalators.	Implement progressive wayfinding signage throughout hallways to provide continuous guidance.
Escalator approaches contain limited safety messaging.	Users may not recognize escalator use as a potential mobility-related hazard.	Increased risk for falls among patients with mobility limitations, fatigue, or assistive devices.	Add human-centered safety messaging and elevator alternatives at escalator entrances.
Signage terminology and visual design are inconsistent across connected buildings.	Inconsistent information increases cognitive burden and reduces confidence in navigation decisions.	Navigation errors and inefficient route selection.	Standardize terminology, symbols, colors, and sign formats across buildings.
Patients exiting a Heart and Vascular Clinic encounter unclear vertical navigation options.	The most visually salient route is the escalator rather than the elevator.	Higher-risk route selection among patients who may have cardiovascular or mobility concerns.	Install directional signage immediately outside the clinic indicating elevator locations and destinations. Include check-out navigation guidance.
Wayfinding support is primarily environmental and not reinforced operationally.	Patients receive little guidance before arriving at navigation decision points.	Continued uncertainty despite environmental improvements.	Include elevator and navigation guidance in appointment reminders, check-in scripts, discharge instructions, check-out communication and website materials.
Current wayfinding system functions as a collection of individual signs rather than an integrated navigation system.	Users must repeatedly interpret isolated pieces of information.	Reduced efficiency and increased navigation errors.	Develop a coordinated wayfinding system using destination-confirmation cues and sequential decision-point guidance.

Based on the walkthrough and incident descriptions, clear navigation challenges were identified between Building 1 and Building 2 and within Building 2. In Building 1, the sign for Elevator Z is not highly visible. Figure 1 shows the escalators leading from Building 1 to Building 2, with limited visibility of signs as users approach the elevators. This view shows the escalator as the most visually prominent vertical transportation option, while Elevator Z is less visible and located off to the side. The image illustrates how limited elevator visibility may influence patients and visitors to select the escalator before recognizing the elevator option. The elevator sign is partially hidden behind and to the left of the escalator, and the elevator label “Z” is not visible until users reach the elevator. The elevators are located to the left of the escalators through a small hallway. Once users enter the hallway to Elevator Z, some signage is present. However, signage at Elevator Z, both outside and inside on floor G, does not provide enough information to confirm that users can access their intended destination.



Figure 1. Escalators and elevator hallway at a decision point between building 1 to building 2.

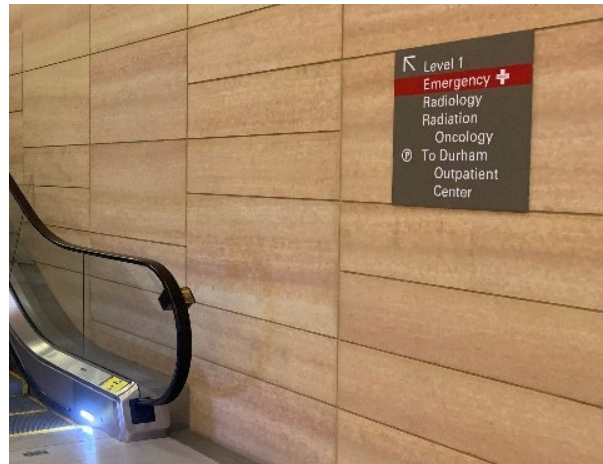


Figure 2. Escalator approach signage with limited safety and destination-confirmation information

The escalator sign (Figure 2) does not include a safety reminder or instructions for individuals with mobility limitations. This image shows the signage near the escalator approach, where safety messaging and alternative elevator guidance are limited. The figure highlights the need for clearer warnings for individuals with mobility limitations and stronger destination-specific wayfinding cues. Directions also remain unclear for some destinations, including specific destinations in Building 2 or Building 3. Two destinations in those buildings were likely to be common navigation targets: the outpatient pharmacy and the Green Parking structure. Other destinations may also generate regular patient and visitor traffic. Therefore, at this decision point, users need more information.

In Building 2, the architectural design includes an open corridor connecting Buildings 2 and 3, with elevators in each building. An elevator is located at each end of the corridor, and two pairs of escalators span two vertical floors along the corridor. In Building 2, escalator signage was limited along the pathway connecting to building 3. A small safety sign (Figure 3) provided limited information and did not include warnings or instructions for individuals with mobility challenges. This image shows existing escalator signage in Building 2, which provides limited safety information and does not clearly direct patients or visitors with mobility challenges to nearby elevator alternatives. The figure supports the recommendation for more visible and human-centered safety messaging at escalator entrances.



Figure 3. Limited escalator safety signage in Building 2.

One location-specific environmental condition was identified for patients exiting the Heart and Vascular Clinic in Building 2. Signage is limited, and directions are unclear. When exiting the clinic, the escalator to level 3 is directly ahead. To the left (Figure 4, left), a long hallway leads toward an elevator in Building 3 with no clear elevator view. To the right (Figure 4, right), the hallway view toward the escalators, which are more visually prominent than nearby elevator routes. The hallway to the elevators in Building 2 is long and partially hidden to the right of the escalator entrance (not visible to the right of Figure 4). With long hallways and limited signage, users may choose the closest and clearest option. In this case, the clearest option is the escalator. Patients visiting the Heart and Vascular Clinic may have mobility challenges and may face wayfinding uncertainty during navigation.



Figure 4. Navigation options from the Heart and Vascular Clinic in Building 2

5.2 Proposed Improvements

To address safety concerns related to escalator fall risk in this academic medical center, proposed improvements include wayfinding system changes, signage enhancements, and operational improvements. Table 1 outlines these proposed improvements for the given observations and anticipated safety risks. Specifically, improved signage is needed to strengthen elevator cues, provide more comprehensive escalator safety information, and offer clearer destination information along navigation paths.

Operational processes can further reinforce environmental improvements. Navigation guidance could be incorporated into check-in and checkout conversations, appointment reminders, website instructions, and phone communications so that patients receive consistent information before and during their visit. Staff-facing prompts may also help identify

patients who would benefit from elevator guidance, particularly those who use mobility aids, report difficulty walking, or appear uncertain about the safest route. Together, these operational supports would extend the wayfinding intervention beyond the physical environment and embed safer navigation choices into routine patient-facing workflows.

The proposed improvements should be implemented as a coordinated wayfinding strategy rather than as isolated sign changes. The most immediate opportunity is to improve elevator visibility at the points where patients and visitors decide between escalators and elevators. Elevator signage should be placed before users commit to a route and should clearly indicate whether the elevator provides access to common destinations such as parking, outpatient clinics, the pharmacy, or connecting buildings. This destination-confirmation information would help reduce uncertainty, support safer route selection, and make elevator use easier for individuals with mobility limitations, fatigue, assistive devices, or unfamiliarity with the facility.

A second area of improvement is the creation of a more continuous and standardized wayfinding system across connected buildings. Progressive signage should guide users from one decision point to the next, rather than relying on a single sign at the destination or elevator bank. This approach is especially important in corridors where elevators are less visually salient than escalators or are located down longer hallways. Standardizing terminology, destination names, elevator labels, and visual design across buildings would also reduce inconsistency and support user confidence as patients and visitors transition between the cancer center, outpatient center, hospital tower, and parking structure.

5.3 Discussion and Inferences

The recommendations developed in this case study are consistent with prior wayfinding, human factors, and escalator safety literature. First, the recommendation to place elevator signage before key decision points reflects wayfinding models that emphasize aligning information cues with users' route-selection decisions. Arthur and Passini (1992) describe wayfinding as a decision-making process supported by environmental information, while Kwon et al. (2025) show that users may miss signage when it does not align with visual attention patterns. In this case study, elevators were less visible than adjacent escalators, suggesting that signage must be positioned where patients and visitors are actively choosing between vertical transportation options.

Second, the recommendation to standardize terminology, destination names, elevator labels, and visual design is consistent with healthcare wayfinding research showing that poor wayfinding increases stress, confusion, and inefficiency. Devlin (2014) and Calori and Vanden-Eynden (2015) emphasize coordinated visual communication systems rather than isolated signs. The observed inconsistencies across connected buildings support the need for a system-wide wayfinding strategy that provides continuous guidance across routes, entrances, parking areas, clinics, and vertical transportation options.

Third, the recommendation to pair escalator safety messaging with visible elevator alternatives is supported by escalator safety literature identifying instability, distraction, failure to hold handrails, and user behavior as contributors to escalator-related injury. Xing et al. (2020) identify behavioral risk factors that increase injury risk, while Gwendiger et al. (2023) and Osipov et al. (2022) emphasize the need to consider user behavior and passenger flow in escalator safety. In this case study, escalators were often the most visible and convenient route, which may increase reliance on a higher-risk option among patients with mobility limitations or fatigue.

Finally, these findings extend the SEIPS framework (Carayon et al. 2006) by illustrating how the built environment, signage, patient tasks, and organizational workflows interact to shape safety outcomes. Navigation guidance should therefore not be treated only as environmental signage, but as part of a broader work system that includes appointment reminders, check-in and checkout communication, staff scripts, and standardized design practices. This inference supports a systems engineering approach in which wayfinding interventions are integrated into both the physical environment and routine patient-facing processes.

Although this assessment did not quantify patient navigation behaviors or escalator utilization rates, it identified several environmental and wayfinding conditions that may influence navigation decisions and increase reliance on escalators. These recommendations should be interpreted with consideration of the case study limitations. The assessment focused on routine wayfinding and navigation under normal operating conditions and did not evaluate emergency egress, high-census crowding, or other non-routine conditions. In addition, while the recommendations are

intended to support a broad range of patients and visitors, additional assessments would be needed to fully address the needs of individuals with visual impairments or other sensory, cognitive, or communication-related accessibility needs.

6. Conclusion

This case study characterized environmental and wayfinding factors that may contribute to escalator use and fall risk, evaluated existing signage systems, and developed targeted human factors recommendations to support safer navigation decisions. This work integrates human factors engineering with architectural design to improve patient safety for patients and visitors navigating an academic medical center. The findings demonstrate the importance of human-centered design for wayfinding activities that involve safety risks, such as escalator use among individuals with mobility challenges. Hospitals should treat wayfinding as a patient safety priority and address it through systems engineering interventions, system-wide standardization, and human-centered design guidelines.

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Biographies

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