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Wayfinding in Hospital Environments: A focus on Signage Systems and Evaluation Approaches

[1]Sobhagya Mittal, [2]Shuvojit Sarkar, [3]Anil Dewan

[1]Research Scholar, [2]Associate Professor, [3]Professor
[1,2,3]Department of Architecture,
[1,2,3]School of Planning and Architecture, Delhi, India

Abstract: Signage is a core component of wayfinding systems in healthcare architecture, directly influencing patient experience, safety, staff efficiency, and operational resilience. Hospitals present unique wayfinding challenges because of programmatic complexity, multiple circulation systems, shifting functional adjacencies, and emotionally stressed users. This study synthesizes theoretical foundations and applied studies on wayfinding and signage, links signage performance to hospital service quality, and explores multi-method approaches for signage evaluation in healthcare environments. Key discussions include legibility and imageability, the four-step natural wayfinding process, decision-point dynamics, signage typologies and physical parameters, and contemporary evaluation methods (inventory audits, POE, usability testing, eye tracking, simulation, and spatial syntax). The paper integrates evidence from a broad literature base to demonstrate how targeted signage strategies reduce cognitive load, lower staff interruptions, shorten travel times, and improve patient satisfaction. Recommendations include a standardized, repeatable signage evaluation protocol combining objective and subjective measures, prioritized interventions at decision points, accessibility checks, and embedding patient feedback into iterative POE cycles to sustain wayfinding performance in hospital settings.

Keywords **– wayfinding, signage, hospital design; decision points, signage evaluation**

I. INTRODUCTION

Wayfinding is a fundamental performance metric for healthcare buildings where timely arrival, clarity in movement, and reduced stress are essential for patient care and operational efficiency (Devlin, 2014; Guo & He, 2022). Hospitals function as complex microcities with multiple programmatic zones—outpatient clinics, imaging, operating theatres, inpatient wards, laboratories, administrative and support services—and often feature layered circulation systems for patients, staff, supplies, and emergency flows (Halawa et al., 2020; Prete et al., 2024). Complexity increases with multi-storey layouts, phased expansions, and ad hoc reconfigurations; these factors exacerbate navigational difficulty for first-time users and even repeat visitors.

Signages serve as the tangible elements of wayfinding by conveying spatial information and suggesting directions at key nodes. Signage interacts closely with architectural form and interior design. Where spatial legibility and strong visual cues exist, reliance on signage can be reduced; where built form is ambiguous, signage must compensate by providing timely, comprehensible information (Bomfim & Cruz, 2023; Iftikhar et al., 2020). Yet many hospitals face either under-signage—yielding uncertainty and missed appointments—or over-signage, which creates visual clutter and cognitive overload (Castor et al., 2023; Lee et al., 2020). Corridor uniformity, indistinct thresholds, inconsistent terminology, and inadequate decision-point signage commonly lead to route errors, delay, and increased staff interruptions.

Unfamiliar users, patients, caregivers, and visitors under stress are especially susceptible to wayfinding failure because they lack robust "knowledge in the head" and therefore rely heavily on "knowledge in the world" embedded in environmental cues (Jamshidi et al., 2020). This interplay between cognitive resources and environmental information underscores the need for integrated wayfinding strategies that align architectural legibility with clear signage systems.

Signage should be understood as an integral component of healthcare architecture, not merely as a graphic overlay. Its design, placement, and condition directly influence user performance, spatial comprehension, and the overall quality of hospital services. A standardized evaluation methodology is essential to connect theoretical and applied findings with practical assessment methods and design prescriptions. Consistent and repeatable evaluation allows for the integration of empirical evidence into findings, thereby strengthening the reliability and validity of signage assessment outcomes. The need for a methodological approach to evaluate signage adequacy and performance in hospitals is both practical and strategic for health facility management and patient-centered design.

II. NEED FOR THIS STUDY

Despite extensive guidance from environmental psychology, information design, and facility management literature, hospitals lack a universally adopted, practical, and empirically grounded method to evaluate signage adequacy and performance (Bubric et al., 2020; Greenroyd et al., 2017). Without standardized evaluation, hospitals oscillate between reactive patchwork signage and

costly overhauls that may not improve wayfinding performance. Two problematic outcomes recur: insufficient signage that produces wayfinding failure and excess signage that overloads users' cognitive systems (Devlin, 2014).

Empirical studies illustrate these issues. Observational Post Occupancy Evaluations (POEs) and usability tests have documented cases where signage inconsistency led to missed appointments, increased late arrivals, and elevated staff interruptions (Zhou et al., 2024). Conversely, hospitals that implemented integrated signage hierarchies, consistent typography, and landmarking reported measurable reductions in navigation time and assistance requests (Lee et al., 2020). However, many existing projects rely on single-method evaluations (e.g., inventories or user surveys) that fail to connect signage condition with operational Key Performance Indicators. The problem is particularly acute for unfamiliar users including outpatients, emergency visitors, and family members, whose high emotional arousal and low environmental knowledge exacerbate navigational errors (Ženka et al., 2021). These user groups require external cues that are timely, legible, and semantically clear. Without a structured approach that links signage attributes such as placement, legibility, and semantics to outcomes like route success rates, time to destination, and staff interruptions, administrators may struggle to prioritize signage interventions effectively.

Therefore, the study promotes an integrated, multi-method approach to signage evaluation in the context of hospitals. It emphasizes identifying critical decision points, measuring both objective route performance and subjective user perceptions, auditing the physical and semantic characteristics of signs, and linking findings to operational metrics to support evidence-based improvements.

III. Literature Review

Wayfinding research integrates insights from environmental psychology, architectural design, human factors, and information design. Foundational theory emphasizes the conversion of external cues into internalized knowledge—helping users form mental maps that support independent navigation (Dalton et al., 2019). Lynch's concepts of legibility and imageability remain central: legibility concerns the ease of reading spatial structure; imageability concerns memorable distinctiveness that supports cognitive mapping (Wessel et al., 2018). In hospitals, legibility is shaped by coherent organization, axial clarity, and distinguishable landmarks such as atria, courtyards, or color-coded zones (Sari & Jabi, 2024).

3.1 Natural wayfinding:

A four-step model of natural wayfinding typically involves four essential functional phases: Orientation, Route Selection, Route Control, and Destination Recognition (Gath-Morad et al., 2021; Passini, 1981). The first phase, Orientation, focuses on establishing one's position relative to the environment, often facilitated by maps and directories. This is followed by Route Selection, where individuals choose among alternative pathways, a process supported by directional signs and sightlines that clearly indicate possible routes. The third phase, Route Control, involves monitoring one's progress along the chosen path and making necessary adjustments. This phase relies on repeated markers and intermediate cues placed strategically along the route to prevent disorientation. Finally, Destination Recognition occurs when the individual confirms arrival at the intended location, a process greatly aided by distinctive landmarks that stand out in the environment (Passini, 1981). Each phase of wayfinding is supported by unique environmental cues tailored to help users progress effectively through the space.

In hospital environments, users naturally select paths that optimize visibility, directness, and perceived safety, with natural paths typically being those that are the straightest, widest, and most visually accessible routes (Teimouri et al., 2023). Key hospital design elements such as main concourses, central atria, and primary corridors often serve as these natural navigational paths. Effective signage strategies should thus focus on leveraging these routes by providing redundant and clear cues at navigational nodes lining these pathways. Such an approach ensures that users receive consistent directional information at critical decision points, aiding their successful navigation through complex hospital layouts. Utilizing a combination of architectural features and signage helps create an intuitive wayfinding experience, reducing cognitive load and stress for hospital visitors and staff alike (Gath-Morad et al., 2021; Passini, 1981; Teimouri et al., 2023).

3.2 Decision Points:

Decision points are pivotal intersections or junctures within hospital circulation networks such as corridor intersections, elevator lobbies, stair landings, and main reception zones where users are required to make route choices that determine the success or failure of navigation. These spatial moments represent cognitive bottlenecks in wayfinding processes, as individuals must interpret environmental cues, signage, and spatial hierarchies simultaneously to proceed correctly. At these nodes, the cognitive load on users tends to peak due to the simultaneous processing of spatial information, directional alternatives, and environmental distractions such as crowd movement or ambient noise. Research highlights that excessive, poorly organized, or contradictory signage at decision points can overload working memory, resulting in confusion, hesitation, and navigation errors (Fan & Choi, 2023; Passini et al., 2000).

Conversely, well-designed decision points support intuitive movement by minimizing mental effort and enhancing spatial comprehension. Effective signage systems at these nodes help reduce decision time by hierarchically prioritizing information, displaying only essential and destination-relevant content, and maintaining consistency in visual language, typography, and color coding. Additionally, spatial layout features such as open sightlines, distinct landmarks, and clear functional zoning contribute to reducing ambiguity and reinforcing the correctness of route selection. Therefore, decision points not only represent architectural thresholds but also cognitive junctures where environmental design and human spatial behavior intersect, profoundly influencing the overall wayfinding experience in complex healthcare facilities. Figure-1 shows the key decision points identified in the OPD zone at AIIMS Jodhpur.

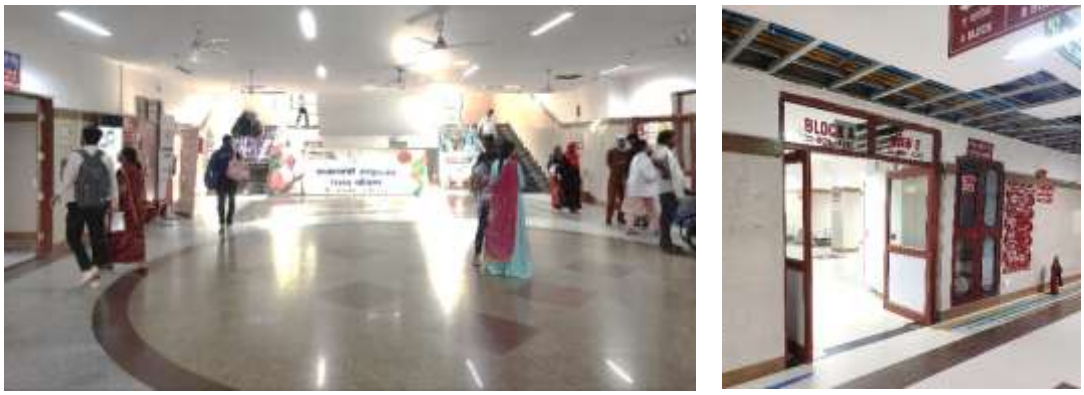

Figure 1: Key decision points identified in the OPD zone at AIIMS Jodhpur

3.3 Typologies and functional classification of signage:

Signage in healthcare environments is typically categorized by function: directional (guides movement), locational (identifies place), informational (provides non-navigational content), regulatory/safety (communicates rules and emergency instructions), and directories or site maps (offers overview orientation) (Iftikhar et al., 2020). These categories support navigation across multiple spatial scales, including campus-level legends, building-level floor directories, department-level identifiers, and room-level labels. The effectiveness of signage systems depends on both visual and cognitive legibility. Visual legibility is shaped by material choices, typography, colour, size, and pictogram clarity, while cognitive legibility is influenced by terminology, phrasing, and semantic coherence (Siyanbola et al., 2023). Together, these attributes determine how users perceive, interpret, and act upon signage information. A well-classified and context-sensitive signage system enhances wayfinding efficiency, reduces navigational errors, and supports inclusive access for diverse user groups. Understanding these typologies is essential for designing and evaluating signage that aligns with spatial logic and user needs. Figure-2 depicts the different signage typologies used in AIIMS Jodhpur.

Figure 2: Different signage typologies in AIIMS Jodhpur

3.4 Legibility, imageability, and spatial differentiation:

Spatial design strategies that contribute to legibility include clear zoning, axial continuity, differentiated floor finishes, and the strategic use of landmarks to support intuitive navigation (Marković et al., 2025). These elements help users interpret spatial hierarchies and anticipate movement patterns. Imageability, defined as the capacity of a space to evoke strong mental representations, is enhanced through memorable features such as public art installations, distinctive architectural forms, and colour-coded facades that anchor cognitive maps and support spatial recall (Ghamari et al., 2025). In hospital environments, spatial differentiation plays a critical role in reducing navigational dependence on signage alone. Well-differentiated floors, clearly marked departmental thresholds, and consistent environmental cues improve recognition-based navigation and facilitate wayfinding for diverse user groups. By integrating legibility and imageability into spatial design, healthcare facilities can promote more efficient, inclusive, and user-friendly navigation experiences, ultimately contributing to improved operational flow and reduced cognitive load for patients and visitors.

3.5 Negative impacts of inadequate signage:

Inadequate or poorly maintained signage in hospital environments contributes to user confusion, heightened stress, delayed arrivals, increased medical no-shows, and the diversion of clinical staff from core duties to provide navigational assistance (Potter, 2017). These disruptions not only affect patient experience but also compromise operational efficiency. Empirical studies have linked poor wayfinding to diminished patient satisfaction and elevated institutional costs resulting from workflow inefficiencies and repeated service delays (Devlin, 2014; Rooke et al., 2023). Addressing signage deficiencies is therefore essential for improving spatial orientation, service delivery, and overall healthcare performance.

IV. PARAMETERS DETERMINING SIGNAGE PERFORMANCE:

The performance of signage is influenced by a coherent set of parameters that are closely tied to both the application type and the spatial context in which the signage is deployed. These parameters include visual characteristics, spatial placement, semantic clarity, quantity, and physical condition. Each of these elements interacts with user needs, circulation patterns, and environmental conditions to shape the overall effectiveness of wayfinding. Accurate assessment of signage performance requires attention to measurable criteria such as legibility distances, mounting height, information density at decision points, illumination levels, and multilingual clarity. Figure-3 depicts different signage installation heights observed at SMS Hospital, Jaipur. Additionally, contextual variables such as user demographics, stress levels, familiarity with the environment, and the complexity of typical routes further mediate how effectively a sign communicates its intended message. Table-1 summarizes these parameters and their key elements.

Table 1: Parameters and key elements determining signage performance

Parameter	Key elements	References
Visual properties	Font type; font size; color; letter spacing; contrast ratio; luminance; pictogram clarity	Beier et al., 2022; Gomez-Hernandez et al., 2023
Placement	Sightlines; mounting height; pre-decision positioning	Bullough, 2017; Carlson et al., 2016
Semantic clarity	Standardized terminology; minimal jargon; usable language; multilingual support	Berrio et al., 2022; Iftikhar et al., 2020
Quantity	Number of destinations shown at a node; avoid excessive density	Iftikhar et al., 2020; Wu et al., 2022
Condition	Maintenance state; lighting; obstructions affecting reliability	Li et al., 2023; Rodrigues et al., 2018; Zhou & Ujang, 2024

A clearly defined set of parameters helps translate assessment findings into actionable design and maintenance decisions. By quantifying visual, spatial, semantic, and condition-related metrics, teams can effectively prioritize interventions that enhance route accuracy, minimize delays, and reduce staff interruptions. Standardized parameter definitions also support benchmarking across hospital typologies and repeated evaluations over time, making incremental improvements measurable and defensible.

Figure 3: Different signage installation heights observed at SMS Hospital, Jaipur

Case studies of hospitals adopting organized wayfinding programs show improvements in travel times, reduced help-desk queries for directions, and improved patient satisfaction (Lee et al., 2020). Key practices include establishing a campus-wide graphic standard, decision-point prioritization, consistent naming conventions, accessible typography standards, dedicated maintenance cycles, and inclusion of stakeholders in signage planning (Bubric et al., 2020; Lee et al., 2020).

V. FACTORS AFFECTING SIGNAGE DESIGN:

Signage design in healthcare environments is shaped by a range of interdependent factors that influence visibility, comprehension, and usability. These factors extend beyond visual aesthetics to include material properties, typographic clarity, directional grammar, ergonomic placement, and semantic consistency. Each parameter must respond to the spatial context, user diversity, and operational demands of the facility. When poorly calibrated, signage can contribute to navigation errors, increased staff burden, and reduced user confidence. Conversely, well-designed signage enhances wayfinding efficiency and institutional credibility. A systematic understanding of these design elements is essential for developing signage that supports both functional navigation and positive user experience. Table-2 outlines key design factors, associated considerations, and representative references that inform evidence-based signage evaluation.

Table 2: Overview of Factors affecting Signage Design in Healthcare Environments

Factor	Details	References
Visual / Material attributes	Contrast; reflective finishes; anti-glare coatings; photometric performance for varied lighting	Bullough, 2017
Typography and scale	Minimum font sizes validated to viewing distance; sans-serif with open counters for quick reading	Dobres et al., 2015; O'Day & Tijerina, 2011
Arrow semantics and directional grammar	Clear continuation cues; avoid ambiguous bifurcation symbols	Beier et al., 2022; Cheng et al., 2022
Color systems	Consistent color coding; avoid conflict with clinical color conventions	Engeset et al., 2022; Snyder et al., 2019
Mounting height and ergonomics	Align to average eye-height; accommodate wheelchair users and pediatric contexts	Villani et al., 2019; Willis et al., 2021
Semantic and administrative consistency	Sign text must match staff terminology and appointment systems to prevent dissonance	Bubric et al., 2020; Rodrigues et al., 2018
Density and clustering	Limit items at decision points; sequence extras via secondary nodes or kiosks	(Lasko et al., 2020; Momenipour et al., 2021)
Maintenance	Regular audits and signholder checks to prevent reduced trust and usability from damaged or outdated signs	(Iftikhar et al., 2020)

Understanding the factors that influence signage performance enables targeted improvements in design, placement, and maintenance. Aligning visual, semantic, and ergonomic attributes with user needs and spatial logic helps reduce wayfinding errors and enhances navigation outcomes. These factors also contribute to accessibility compliance and foster user trust in the built environment. When systematically assessed, they offer a foundation for replicable and context-sensitive signage strategies. Such strategies not only improve user experience but also support operational efficiency across diverse hospital typologies, ensuring that signage functions as an integral component of healthcare delivery and spatial communication.

VI. SIGNAGE EVALUATION METHODS:

Evaluating signage systems in healthcare environments requires a multi-method approach that balances technical precision with user experience insights. Signage evaluation combines practical inspection and user-centred measurement to assess how effectively signs support movement, decision-making, and user confidence. A comprehensive approach integrates spatial audits, behavioural testing, visual analytics, and participatory feedback, enabling institutions to capture both physical condition and cognitive usability. These methods must be feasible across diverse hospital typologies, sensitive to accessibility needs, and capable of linking observed shortcomings to operational consequences such as staff interruptions, delayed routing, or patient dissatisfaction. By combining simple audits with behavioural tasks and quantitative performance metrics, findings become directly actionable for facilities teams, designers, and healthcare managers. Adaptability to contextual realities and responsiveness to user diversity are essential for generating insights that inform design improvements, maintenance priorities, and long-term strategic planning. Table-3 outlines key evaluation methods for signages.

6.1 Rationale for systematic evaluation:

Signage evaluation plays a critical role in hospital quality management, as it directly influences patient safety, service punctuality, and staff workflow efficiency. In complex healthcare environments, signage functions as a navigational interface that supports spatial orientation and operational flow. A systematic and integrated evaluation approach enables the correlation of signage attributes with key outcome indicators, including route-finding success rates, average time-to-destination, frequency of staff interruptions, and patient satisfaction scores (Bubric et al., 2020). These metrics provide objective evidence of signage performance and its contribution to institutional effectiveness. Without linking signage interventions to measurable outcomes, improvements may remain superficial, addressing only aesthetic or isolated concerns rather than yielding functional benefits. Outcome-oriented evaluation ensures that signage systems are not only visually coherent but also operationally responsive. It enables facilities teams and decision-makers to prioritise interventions that enhance wayfinding, reduce inefficiencies, and improve the overall healthcare experience for patients, visitors, and staff.

6.2 Typologies and functions:

Hospitals implement a diverse range of signage types to facilitate wayfinding, communication, and safety across complex environments. These include directional signs, locational signs, directories or site maps, safety and regulatory signs, and informational signs (Rodrigues et al., 2018). Directional signage typically represents the largest proportion of a hospital's wayfinding system, as it supports movement across multiple spatial scales and decision points. Studies indicate that directional elements may constitute approximately 40-60% of signage assets in large public facilities, while locational and directory signage form the remaining balance (Iftikhar et al., 2020; Miller & Lewis, 2000). Each signage type serves a distinct functional role, contributing to spatial orientation, user confidence, and operational flow. Understanding the distribution and purpose of these typologies is essential for designing signage systems that align with user needs, institutional workflows, and environmental complexity. A functionally balanced signage system enhances wayfinding efficiency and supports inclusive access across diverse hospital contexts.

Table 3: Summary of Methodological Approaches for Signage Evaluation

Method	Description	References
Inventory and Condition Audit	Creates a spatially referenced database of signage assets with geotagged photos and condition codes for maintenance planning	Mandel & Johnston, 2017; Pratelli et al., 2023
Post-Occupancy Evaluation (POE)	Mixed-method assessment combining inventories, timed route tasks, user interviews, staff logs, and service metrics	Deng et al., 2023; Mandel & Johnston, 2017; Pereira et al., 2016
Usability Testing	Scenario-based tasks with representative users to measure success rates, time, and error patterns	Bubric et al., 2020; Dubey et al., 2019
Eye-Tracking and Attention Studies	Identifies visual attention patterns to refine typography and layout of signage	Chana et al., 2023; Zhou & Ujang, 2024
Visibility and Contrast Testing	Uses photometric and contrast ratio analysis to ensure readability at design distances	Iftikhar et al., 2020; Li et al., 2023
Simulation and Agent-Based Models	Predicts flow and congestion; tests alternative signage placements in virtual environments	Dubey et al., 2019; Guo & He, 2022
Spatial Syntax / Nodal Analysis	Identifies high-integration routes and critical decision nodes for prioritized signage	Greenroyd et al., 2017; Guo & He, 2022
Accessibility Audits	Evaluates tactile, braille, color contrast, and cognitive accessibility compliance	Ma & Yang, 2025; Suo et al., 2023
Ergonomic and Human Factors Analysis	Reviews mounting height, reading distance, and information clustering using anthropometric data	Berrio et al., 2022; Silva, 2022
Participatory and Co-design Workshops	Engages patients, families, and staff to align signage semantics and priorities	Basri & Sulaiman, 2013; Bubric et al., 2020; Wu et al., 2022

A comprehensive evaluation strategy enables healthcare institutions to identify signage gaps, validate design decisions, and align wayfinding systems with user needs. By triangulating data from spatial, behavioural, ergonomic, and participatory sources, teams can develop targeted interventions that enhance navigation, reduce staff burden, and improve patient experience. These methods also support benchmarking, compliance with accessibility standards, and iterative refinement over time. When applied systematically, they form the backbone of an evidence-based signage program that is both operationally effective and user-centred.

VII. Findings and Discussion:

7.1 Decision points as focal targets:

Decision points consistently emerge as the most important intervention sites, and targeted improvements at these critical nodes yield large gains in route accuracy and reduced hesitation times (Morag et al., 2023; Zheng & Chang, 2021). Ensuring clear pre-node signage, prioritized destination lists, and adequate pause space reduces backtracking and improves flow. The density, clustering, and hierarchy of decision points determine wayfinding complexity and directly inform signage placement, information prioritization, and expected decision times for users. Decision points should be analyzed for the number of potential destinations visible, available pause space, and pre-node sightlines. Evidence suggests that using a staged hierarchy of signs, placing primary destinations first and secondary destinations on subsequent signs, improves wayfinding by reducing cognitive load and wrong turn (Hu & Xu, 2022; Mishler & Neider, 2016). Clustering of numerous signs at a single node should be avoided; instead, distribute information across sequential decision points and integrate digital directories for comprehensive listings.

7.2 Condition, maintenance, and trust:

The trust that users place in a hospital's signage system is closely tied to the perceived currency and physical integrity of the signs. When signage appears well-maintained, up to date, and clearly visible, users are more likely to rely on it for navigation. In contrast, damaged, outdated, or obscured signs diminish user confidence, increase cognitive load, and often lead to higher rates of staff interruption for directional assistance (Rodrigues et al., 2020; Taylor, 2022). To sustain trust and functionality, maintenance protocols should incorporate scheduled audits, defined replacement cycles, and rapid-refresh mechanisms following departmental renaming, spatial reconfigurations, or policy changes. Proactive maintenance not only supports wayfinding efficiency but also reinforces the institution's commitment to user-centred care and operational excellence.

7.3 Synthesis:

Integrating signage evaluation with broader hospital service quality frameworks ensures that wayfinding metrics contribute meaningfully to resource allocation, patient experience benchmarks, and safety protocols. Signage systems are not isolated design features but operational tools that influence spatial efficiency, user confidence, and institutional credibility. To be effective, signage evaluation must connect to key performance indicators such as average wayfinding time, route success rate, frequency of directional assistance requests, and patient satisfaction scores. These indicators offer quantifiable insights into how signage affects both user navigation and staff workflows. A multi-method assessment that combines spatial audits, behavioral testing, and user feedback allows healthcare institutions to link signage interventions directly to operational improvements and cost savings. This includes reducing misrouting incidents, minimizing missed appointments, and lowering staff time spent on navigational support (Morag & Pintelon, 2020; Sahoo et al., 2024).

7.4 Environmental familiarity for various user groups:

Environmental familiarity strongly moderates wayfinding success. Staff and frequent visitors rely on internalized mental maps and require fewer external cues whereas first-time users, emergency patients, and visitors depend heavily on external cues and signage (Jamshidi et al., 2020; Ženka et al., 2021). Signage strategies should be differentiated, with multiple complimentary cues and simplified messages at entrances and outpatient areas for novice users and streamlined, semantically consistent signage in staff and back of house zones.

7.5 Patient perceptions and semantic clarity:

Patient satisfaction correlates with clarity, consistency, placement, and visibility of signages. Studies show that patients prefer concise language, consistent iconography, and predictable signage locations during wayfinding. Discrepancies between administrative naming and patient-facing terminology cause confusion and should be reconciled (Devlin, 2014; Sahoo et al., 2024).

Wayfinding design can be systematically addressed through four interacting factors:

- Overall configuration: macro spatial organization and coherence.
- Signage systems: graphic standards, placement rules, message hierarchies.
- Visual contact: sightlines and unobstructed views supporting orientation.
- Space differentiation: material and lighting strategies creating distinctive regions

(Bianconi et al., 2021; Bomfim & Cruz, 2023; Lee et al., 2020; Li et al., 2023).

Recent work emphasizes multi-method POE, integration of digital wayfinding aids (mobile wayfinding apps, interactive kiosks), and use of eye-tracking and simulation for refinement (Devlin, 2014; Gath-Morad et al., 2024). Hospitals should be adopting standardized graphic languages across networks to support predictable wayfinding while permitting local spatial customization. Table-4 presents consolidated findings and takeaways.

Table 4: Consolidated findings and takeaways

Topic	Key Finding	Practical Takeaway
Environmental familiarity	Novice users rely on external cues; familiar users rely on mental maps	Prioritize series of connecting signages at entrances and outpatient zones
Decision points	Highest risk of wayfinding errors	Place prioritized legible signs before nodes, don't over clutter
Signage condition	Damaged/obstructed signs reduce trust	Conduct regular signage maintenance audits
Signage quantity	Both scarcity and abundance hamper wayfinding	Limit items per node; sequence information
Typography& visibility	Poor contrast and small fonts impede legibility	Use tested font sizes and contrast ratios
Semantic consistency	Conflicting terminology confuses users	Standardize names & symbols across systems
Accessibility	Visual and cognitive impairments need accommodation	Include tactile, braille, and simple pictograms
Evaluation methods	Multi-method approaches yield comprehensive insights	Combine POE, usability testing, inventory audits

VIII. CONCLUSION:

Signage is a critical service quality component of healthcare architecture and demands a rigorous, multi method evaluation approach. Post-Occupancy Evaluation (POE) is indispensable for linking signage to measurable outcomes. POE should assess signage placement, legibility, semantics and condition and relate these attributes to route success rates, average wayfinding time, staff interruption frequency and patient satisfaction. Effective signage reduces dependency on staff for directions, shortens delays, supports patient safety by clarifying emergency routes, and yields cost savings by minimizing wayfinding-related inefficiencies.

Recommendations:

1. Adopt a customized signage evaluation approach that combines key pointers from inventory audit, timed route tasks, user surveys, eye-tracking, space syntax analysis and a few operational KPIs to track wayfinding performance.
2. Prioritize interventions at decision points: pre-node signage, limit destinations per node, and ensure adequate pause/clearance space.
3. Standardize semantics and graphic language across the built environment and align nomenclature with staff systems to avoid dissonance.
4. Implement accessibility checks covering low vision, tactile and cognitive needs and ensure mounting heights and viewing distances are inclusive.
5. Establish maintenance cycles and condition audits to ensure consistent signage performance.
6. Engage patients and frontline staff through participatory design workshops to validate terminology and priorities.
7. Integrate digital wayfinding (kiosks, mobile apps) as supplementary layers while preserving robust physical signage for reliability.

Translating these recommendations into a structured and repeatable evaluation process can shift wayfinding from an ad hoc facility concern to a measurable component of healthcare performance. Future research should validate threshold values for signage density at decision points, empirically derive optimal font-size/viewing-distance tables for hospital contexts, and evaluate

the cost versus benefit of implementing integrated signage across multiple hospital typologies. An effective signage system is a low-to-moderate cost intervention that can deliver substantial returns for patient experience, safety, and operational efficiency. Embedding systematic evaluation and iterative improvement ensures healthcare architecture supports users under stress and enhances overall hospital performance.

REFERENCES

1. Basri, A. Q., & Sulaiman, R. (2013). Ergonomics Study of Public Hospital Signage. Advanced Engineering Forum, 10, 263. https://doi.org/10.4028/www.scientific.net/aef.10.263
2. Beier, S., Berlow, S., Boucaud, E., Bylinskii, Z., Cai, T., Cohn, J., Crowley, K., Day, S., Dingler, T., Dobres, J., Healey, J., Jain, R., Jordan, M., Kerr, B. J., Li, Q., Miller, D., Nobles, S., Papoutsaki, A., Qian, J., … Wolfe, B. (2022). Readability Research: An Interdisciplinary Approach. Foundations and Trends in Human-Computer Interaction, 16(4), 214. https://doi.org/10.1561/1100000089
3. Berrio, S., Barrero, L. H., Zambrano, L., & Papadimitriou, E. (2022). Ergonomic factors affecting comprehension levels of traffic signs: A critical review [Review of Ergonomic factors affecting comprehension levels of traffic signs: A critical review]. International Journal of Transportation Science and Technology, 12(3), 848. Elsevier BV. https://doi.org/10.1016/j.ijtst.2022.08.004
4. Bianconi, F., Filippucci, M., Magrini, G., & Seccaroni, M. (2021). DESIGNING WITH EMOTIONAL AWARENESS. The international Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences/International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 55. https://doi.org/10.5194/isprs-archives-xlvi-m-1-2021-55-2021
5. Bomfim, L. C., & Cruz, S. S. (2023). Understanding Spatial Cognition for Designing Pedestrian Wayfinding Systems. U Porto Journal of Engineering, 9(2), 132. https://doi.org/10.24840/2183-6493_009-002_002081
6. Bubric, K., Harvey, G., & Pitamber, T. (2020). A User-Centered Approach to Evaluating Wayfinding Systems in Healthcare. HERD Health Environments Research & Design Journal, 14(1), 19. https://doi.org/10.1177/1937586720959074
7. Bullough, J. D. (2017). Factors Affecting Sign Visibility, Conspicuity, and Legibility: Review and Annotated Bibliography. Interdisciplinary Journal of Signage and Wayfinding, 1(2), 2. https://doi.org/10.15763/ijsw.v1i2.9
8. Carlson, P. J., Brimley, B. K., Miles, J., Chrysler, S. T., Gibbons, R., & Terry, T. (2016). Guidelines for Nighttime Visibility of Overhead Signs. In Transportation Research Board eBooks. https://doi.org/10.17226/23512
9. Castor, C. J., Datuin, A. D. A., Anjelo, A., Realon, J. M., & Esmeria, G. J. (2023). Approaches in Evaluating Hospital Wayfinding Signage System: A Literature Review [Review of Approaches in Evaluating Hospital Wayfinding Signage System: A Literature Review]. https://doi.org/10.46254/an13.20230651
10. Chana, K., Mikuni, J., Schnebel, A., & Leder, H. (2023). Reading in the city: mobile eye-tracking and evaluation of text in an everyday setting. Frontiers in Psychology, 14. https://doi.org/10.3389/fpsyg.2023.1205913
11. Cheng, Y., Xia, Z., Ye, M., & Liwei, T. (2022). Usability Evaluation of in-Vehicle AR-HUD Interface Applying AHP-GRA. Human-Centric Intelligent Systems, 2, 124. https://doi.org/10.1007/s44230-022-00011-1
12. Cho, H., Powell, D., Pichon, A., Kuhns, L. M., Garofalo, R., & Schnall, R. (2019). Eye-tracking retrospective think-aloud as a novel approach for a usability evaluation. International Journal of Medical Informatics, 129, 366. https://doi.org/10.1016/j.ijmedinf.2019.07.010
13. Dalton, R., Hölscher, C., & Montello, D. R. (2019). Wayfinding as a Social Activity. Frontiers in Psychology, 10. https://doi.org/10.3389/fpsyg.2019.00142
14. Deng, L., Romainoor, N. H., & Zhang, B. (2023). Evaluation of the Usage Requirements of Hospital Signage Systems Based on the Kano Model. Sustainability, 15(6), 4972. https://doi.org/10.3390/su15064972
15. Devlin, A. S. (2014). Wayfinding in Healthcare Facilities: Contributions from Environmental Psychology [Review of Wayfinding in Healthcare Facilities: Contributions from Environmental Psychology]. Behavioral Sciences, 4(4), 423. Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/bs4040423
16. Dobres, J., Chahine, N., Reimer, B., Gould, D., & Zhao, N. (2015). The effects of Chinese typeface design, stroke weight, and contrast polarity on glance based legibility. Displays, 41, 42. https://doi.org/10.1016/j.displa.2015.12.001
17. Dubey, R. K., Thrash, T., Kapadia, M., Höelscher, C., & Schinazi, V. R. (2019). Information Theoretic Model to Simulate Agent-Signage Interaction for Wayfinding. Cognitive Computation, 13(1), 189. https://doi.org/10.1007/s12559-019-09689-1
18. Engeset, R., Pfuhl, G., Orten, C., Hendrikx, J., & Hetland, A. (2022). Colours and maps for communicating natural hazards to users with and without colour vision deficiency. International Journal of Disaster Risk Reduction, 76, 103034. https://doi.org/10.1016/j.ijdrr.2022.103034
19. Fan, J., & Choi, A. Y. (2023). Cognitive Load Theory Analysis of Medical Signage System for Seniors Based on General Hospitals in Shanghai. In Springer series in design and innovation (p. 542). Springer International Publishing. https://doi.org/10.1007/978-3-031-47281-7_45
20. Filippidis, L., Xie, H., Galea, E. R., & Lawrence, P. (2021). Exploring the potential effectiveness of dynamic and static emergency exit signage in complex spaces through simulation. Fire Safety Journal, 125, 103404. https://doi.org/10.1016/j.firesaf.2021.103404
21. Gath-Morad, M., Grübel, J., Steemers, K., Sailer, K., Ben-Alon, L., Hölscher, C., & Aguilar, L. (2024). The role of strategic visibility in shaping wayfinding behavior in multilevel buildings. Scientific Reports, 14(1). https://doi.org/10.1038/s41598-024-53420-6
22. Gath-Morad, M., Thrash, T., Schicker, J., Hölscher, C., Helbing, D., & Aguilar, L. (2021). Visibility matters during wayfinding in the vertical. Scientific Reports, 11(1). https://doi.org/10.1038/s41598-021-98439-1
23. Ghamari, M., Suvish, Dehkordi, A. A., See, C. H., Sami, A., Yu, H., & Sundaram, S. (2025). Dementia Friendly Buildings—Approach on Architectures. Buildings, 15(3), 385. https://doi.org/10.3390/buildings15030385
24. Gomez-Hernandez, M., Ferré, X., Moral, C., & Villalba‐Mora, E. (2023). Design Guidelines of Mobile Apps for Older Adults: Systematic Review and Thematic Analysis [Review of Design Guidelines of Mobile Apps for Older Adults:

Systematic Review and Thematic Analysis]. JMIR Mhealth and Uhealth, 11. JMIR Publications. https://doi.org/10.2196/43186
25. Greenroyd, F. L., Hayward, R., Price, A., Demian, P., & Sharma, S. (2017). A tool for signage placement recommendation in hospitals based on wayfinding metrics. Indoor and Built Environment, 27(7), 925. https://doi.org/10.1177/1420326x17695375
26. Guo, W., & He, Y. (2022). Optimized Wayfinding Signage Positioning in Hospital Built Environment through Medical Data and Flows Simulations. Buildings, 12(9), 1426. https://doi.org/10.3390/buildings12091426
27. Halawa, F., Madathil, S. C., Gittler, A. M., & Khasawneh, M. T. (2020). Advancing evidence-based healthcare facility design: a systematic literature review [Review of Advancing evidence-based healthcare facility design: a systematic literature review]. Health Care Management Science, 23(3), 453. Springer Science+Business Media. https://doi.org/10.1007/s10729-020-09506-4
28. Hu, X., & Xu, L. (2022). How Guidance Signage Design Influences Passengers' Wayfinding Performance in Metro Stations: Case Study of a Virtual Reality Experiment. Transportation Research Record Journal of the Transportation Research Board, 2677(1), 1118. https://doi.org/10.1177/03611981221103591
29. Iftikhar, H., Asghar, S., & Luximon, Y. (2020). A cross-cultural investigation of design and visual preference of signage information from Hong Kong and Pakistan. Journal of Navigation, 74(2), 360. https://doi.org/10.1017/s0373463320000521
30. Jamshidi, S., Ensafi, M., & Pati, D. (2020). Wayfinding in Interior Environments: An Integrative Review [Review of Wayfinding in Interior Environments: An Integrative Review]. Frontiers in Psychology, 11. Frontiers Media. https://doi.org/10.3389/fpsyg.2020.549628
31. Jensen, P. A. (2014). Proceedings of CIB Facilities Management Conference : Using Facilities in an open World creating Value for all Stakeholders. In Research Portal Denmark (p. 483). Technical University of Denmark.
32. Lasko, T. A., Owens, D. A., Fabbri, D., Wanderer, J. P., Genkins, J. Z., & Novak, L. L. (2020). User-Centered Clinical Display Design Issues for Inpatient Providers. Applied Clinical Informatics, 11(5), 700. https://doi.org/10.1055/s-0040-1716746
33. Ledesma, A., Al-Musawi, M., & Nieminen, H. (2016). Health figures: an open source JavaScript library for health data visualization. BMC Medical Informatics and Decision Making, 16(1). https://doi.org/10.1186/s12911-016-0275-6
34. Lee, E., Daugherty, J., Selga, J., & Schmidt, U. (2020). Enhancing Patients' Wayfinding and Visitation Experience Improves Quality of Care [Review of Enhancing Patients' Wayfinding and Visitation Experience Improves Quality of Care]. Journal of PeriAnesthesia Nursing, 35(3), 250. Elsevier BV. https://doi.org/10.1016/j.jopan.2019.11.003
35. Li, C., Guo, H., Yin, M., Zhou, X., Zhang, X., & Ji, Q. (2023). A Systematic Review of Factors Influencing Signage Salience in Indoor Environments [Review of A Systematic Review of Factors Influencing Signage Salience in Indoor Environments]. Sustainability, 15(18), 13658. Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/su151813658
36. Ma, X., & Yang, Q. (2025). Research on the Spatial Location Design of Guidance Signage Systems to Connect the Space of Transit-Orientated Development Sites Based on Multi-Software Analysis. Buildings, 15(5), 683. https://doi.org/10.3390/buildings15050683
37. Mandel, L. H., & Johnston, M. P. (2017). Evaluating library signage: A systematic method for conducting a library signage inventory. Journal of Librarianship and Information Science, 51(1), 150. https://doi.org/10.1177/0961000616681837
38. Marković, S., Alfirevic, D., Simonović-Alfirević, S., & Nikolić, S. (2025). Principles for Achieving Legibility in Residential Spaces: A Synthesis of Cognitive and Perceptual Approaches. Buildings, 15(8), 1243. https://doi.org/10.3390/buildings15081243
39. Miller, C., & Lewis, D. (2000). Wayfinding in complex healthcare environments. Information Design Journal, 9, 129. https://doi.org/10.1075/idj.9.2-3.04mil
40. Mishler, A., & Neider, M. B. (2016). Improving Wayfinding for Older Users With Selective Attention Deficits. Ergonomics in Design The Quarterly of Human Factors Applications, 25(1), 11. https://doi.org/10.1177/1064804616659992
41. Momenipour, A., Rojas-Murillo, S., Murphy, B., Pennathur, P. R., & Pennathur, A. (2021). Usability of state public health department websites for communication during a pandemic: A heuristic evaluation. International Journal of Industrial Ergonomics, 86, 103216. https://doi.org/10.1016/j.ergon.2021.103216
42. Morag, I., & Pintelon, L. (2020). Digital wayfinding systems in hospitals: A qualitative evaluation based on managerial perceptions and considerations before and after implementation. Applied Ergonomics, 90, 103260. https://doi.org/10.1016/j.apergo.2020.103260
43. Morag, I., Sönmez, V., Puyvelde, A. V., & Pintelon, L. (2023). Improving wayfinding in hospitals for people with diverse needs and abilities: An exploratory approach based on multi-criteria decision making. Applied Ergonomics, 114, 104149. https://doi.org/10.1016/j.apergo.2023.104149
44. O'Day, S., & Tijerina, L. (2011). Legibility: Back to the Basics. SAE International Journal of Passenger Cars - Mechanical Systems, 4(1), 591. https://doi.org/10.4271/2011-01-0597
45. Passini, R. (1981). Wayfinding: A conceptual framework. Urban Ecology, 5(1), 17. https://doi.org/10.1016/0304-4009(81)90018-8
46. Passini, R., Pigot, H., Rainville, C., & Tétreault, M.-H. (2000). Wayfinding in a Nursing Home for Advanced Dementia of the Alzheimer's Type. Environment and Behavior, 32(5), 684. https://doi.org/10.1177/00139160021972748
47. Pereira, N. B., Rodrigues, R. C., & Rocha, P. F. (2016). Post-Occupancy Evaluation Data Support for Planning and Management of Building Maintenance Plans. Buildings, 6(4), 45. https://doi.org/10.3390/buildings6040045
48. Potter, J. S. (2017). Best Practices for Wayfinding in a Hospital Setting. https://scholarsbank.uoregon.edu/xmlui/handle/1794/22565
49. Pratelli, A., Brocchini, L., Leandri, P., Carlo, M. D., & Martini, L. (2023). Dynamic Planning of Vertical Road Signs Maintenance: Operational Methodology. Transportation Research Procedia, 73, 25. https://doi.org/10.1016/j.trpro.2023.11.887
50. Prete, D., Piscitelli, P., & Elia, G. (2024). Govern complex systems in the design of an innovative, safe and sustainable hospital. E3S Web of Conferences, 523, 2004. https://doi.org/10.1051/e3sconf/202452302004
51. Rodrigues, R., Coelho, R., & Tavares, J. M. R. S. (2018). Healthcare Signage Design: A Review on Recommendations for Effective Signing Systems [Review of Healthcare Signage Design: A Review on Recommendations for Effective Signing

Systems]. HERD Health Environments Research & Design Journal, 12(3), 45. SAGE Publishing. https://doi.org/10.1177/1937586718814822
52. Rodrigues, R., Coelho, R., & Tavares, J. M. R. S. (2020). Users' Perceptions of Signage Systems at Three Portuguese Hospitals. HERD Health Environments Research & Design Journal, 13(3), 36. https://doi.org/10.1177/1937586720924761
53. Rooke, C. N., Rooke, J., Tzortzopoulos, P., & Koskela, L. (2023). Wayfinding in Complex Medical Facilities: The Indexicality of Directional Arrows. HERD Health Environments Research & Design Journal, 16(4), 118. https://doi.org/10.1177/19375867231180908
54. Sahoo, B., Pillai, J. S. K., Md, S., & Sahoo, M. C. (2024). Implementation of Wayfinding Signage in Public Hospitals and Its Evaluation Towards Quality Improvement. Cureus. https://doi.org/10.7759/cureus.65435
55. Sari, A. O. B., & Jabi, W. (2024). Architectural Spatial Layout Design for Hospitals: A Review [Review of Architectural Spatial Layout Design for Hospitals: A Review]. Journal of Building Engineering, 110835. Elsevier BV. https://doi.org/10.1016/j.jobe.2024.110835
56. Silva, J. N. a F. M. da. (2022). Wayfinding Design: An Ergonomic Approach to Signage Systems. AHFE International. https://doi.org/10.54941/ahfe100771
57. Siyanbola, A. B., Oladesu, J. O., Afolabi, B. E. F., & Uzzi, F. O. (2023). Adapting Flat Design Concept in Digital Graphics to Wayfinding Signage Development: Redirecting Movement and Recreating the Environment. Journal of Visual Communication Design, 8(1), 130. https://doi.org/10.37715/vcd.v8i1.3207
58. Snyder, M. E., Jaynes, H. A., Gernant, S. A., Diiulio, J., Militello, L. G., Doucette, W. R., Adeoye‐Olatunde, O. A., & Russ, A. L. (2019). Alerts for community pharmacist-provided medication therapy management: recommendations from a heuristic evaluation. BMC Medical Informatics and Decision Making, 19(1). https://doi.org/10.1186/s12911-019-0866-0
59. Sørensen, K. M., & Holst, C. (2019). Academic library services in Learning Management Systems (LMS) : Methodologies for evaluating digital library content and system usability. Research Portal Denmark.
60. Suo, Y., Lei, B., Xun, T., Li, N., Lei, D., Lin-lin, L., & Cao, X.-Q. (2023). Optimization Method of Subway Station Guide Sign Based on Pedestrian Walking Behavior. Sustainability, 15(17), 12690. https://doi.org/10.3390/su151712690
61. Taylor, C. (2022). Academic Research on Signage: Research Directions to Add Value for Stakeholders. Interdisciplinary Journal of Signage and Wayfinding, 6(1), 21. https://doi.org/10.15763/issn.2470-9670.2022.v6.i1.a109
62. Teimouri, F., Richter, K., & Hochmair, H. H. (2023). Analysis of route choice based on path characteristics using Geolife GPS trajectories. Journal of Location Based Services, 17(3), 271. https://doi.org/10.1080/17489725.2023.2229285
63. Villani, V., Sabattini, L., Loch, F., Vogel‐Heuser, B., & Fantuzzi, C. (2019). A General Methodology for Adapting Industrial HMIs to Human Operators. IEEE Transactions on Automation Science and Engineering, 18(1), 164. https://doi.org/10.1109/tase.2019.2941541
64. Wessel, G., Karduni, A., & Sauda, É. (2018). The Image of the Digital City: Revisiting Lynch's Principles of Urban Legibility. Journal of the American Planning Association, 84, 280. https://doi.org/10.1080/01944363.2018.1524716
65. Willis, M., Hein, L. B., Hu, Z., Saran, R., Argentina, M., Bragg‐Gresham, J. L., Krein, S. L., Gillespie, B. W., Zheng, K., & Veinot, T. C. (2021). Usability Evaluation of a Tablet-Based Intervention to Prevent Intradialytic Hypotension in Dialysis Patients During In-Clinic Dialysis: Mixed Methods Study. JMIR Human Factors, 8(2). https://doi.org/10.2196/26012
66. Wu, J., Liu, X., Lu, C., Yu, S., Jiao, D., Ye, X., & Zhu, Y. (2022). A Design Framework of Medical Wayfinding Signs for the Elderly: Based on the Situational Cognitive Commonness. International Journal of Environmental Research and Public Health, 19(21), 13885. https://doi.org/10.3390/ijerph192113885
67. Ženka, J., Macháček, J., Michna, P., & Kořízek, P. (2021). Navigational Needs and Preferences of Hospital Patients and Visitors: What Prospects for Smart Technologies? International Journal of Environmental Research and Public Health, 18(3), 974. https://doi.org/10.3390/ijerph18030974
68. Zhao, H., Schwabe, A., Schläfli, F., Thrash, T., Aguilar, L., Dubey, R. K., Karjalainen, J., Hölscher, C., Helbing, D., & Schinazi, V. R. (2021). Fire evacuation supported by centralized and decentralized visual guidance systems. Safety Science, 145, 105451. https://doi.org/10.1016/j.ssci.2021.105451
69. Zheng, M.-C., & Chang, K.-T. (2021). Design Verification of an Optimized Wayfinding Map in a Station. ISPRS International Journal of Geo-Information, 10(4), 266. https://doi.org/10.3390/ijgi10040266
70. Zhou, J., & Ujang, N. (2024). An Analysis of Pedestrian Preferences for Wayfinding Signage in Urban Settings: Evidence from Nanning, China. Buildings, 14(9), 2986. https://doi.org/10.3390/buildings14092986
71. Zhou, J., Ujang, N., Manan, M. S. A., & Aziz, F. A. (2024). Bridging Perceptual Gaps: Designers vs. Non-Designers in Urban Wayfinding Signage Preferences. Sustainability, 16(22), 9653. https://doi.org/10.3390/su16229653