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Vertical Social Infrastructures: Redefining Community Interaction in High-Rise Urban Housing

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Abstract. *This study examines how graphic design functions as a social infrastructure within high-rise urban housing, shaping interactions, identity, and collective well-being. Urbanization has driven vertical expansion, creating new spatial and social challenges that affect community cohesion. While existing research in architecture and urban sociology has focused on spatial design and technological efficiency, this study highlights the overlooked role of visual communication as an active mediator of social relations. The research introduces the concept of Vertical Social Infrastructures, which reframes high-rise housing as a visual–social system rather than merely a physical structure. Using comparative analysis, the study explores how graphic elements, color, signage, murals, and typography can guide interaction and create shared narratives in dense residential settings. The study explicitly contributes to the field of graphic design by demonstrating how visual communication — including color, signage, murals, and typography — mediates social interaction and spatial behavior in vertical housing environments. This connection reinforces the journal's focus on the intersections between design, media, and society, positioning graphic design as both an analytical and infrastructural framework for community engagement. The findings demonstrate that graphic design serves as a connective infrastructure, enhancing spatial legibility and fostering social engagement. By integrating theories from design studies, social infrastructure, and urban communication, this paper contributes a cross-disciplinary framework for understanding design as a medium of social sustainability. The results suggest that visual design strategies can transform vertical housing into inclusive, participatory, and emotionally resonant environments.*

Keywords: *Vertical Social Integration, Interactive Urban Living, Community-Centric High-Rise Design, Spatial Engagement Strategies, Humanized Vertical Architecture*

INTRODUCTION

Urbanization has reshaped the spatial and social dynamics of modern cities, pushing residential development into vertical forms that fundamentally alter how communities interact. Recent demographic projections indicate that by 2050, nearly 70% of the world's population will reside in urban areas, with high-rise housing becoming the dominant solution to land scarcity and increasing density (Zamojski, 2022). While vertical living addresses the spatial limitations of cities, it simultaneously creates challenges in sustaining social cohesion and community well-being (Lestari et al., 2025; Prihatmoko & Setiyadi, 2024; Priyadi & Slamet, 2024). Research in urban sociology and architecture has emphasized that the rapid expansion of high-rise developments often neglects the quality of human interactions within shared environments, leading to social isolation, diminished communal identity, and fragmented everyday experiences (Buttazzoni et al., 2022; Xu et al., 2023). As illustrated in Figure 1, both the global percentage of urban populations and the growth of high-rise housing show a significant upward trend from 1990 to 2050, highlighting the urgency of addressing not only structural but also social dimensions of vertical living.

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To strengthen the theoretical grounding of this study, foundational design theory is incorporated. (Cross, 2001) emphasizes “designerly ways of knowing,” positioning design as a reflective, problem-solving practice; (Buchanan, 1992) frames design as a moral and socially responsive discipline. Integrating these perspectives positions graphic design as more than aesthetic enhancement: it becomes an infrastructural mediator of social relations in vertical housing. This study introduces the concept of 'Vertical Social Infrastructures' as a novel interpretive framework that reframes high-rise housing beyond its architectural and economic dimensions. Unlike previous frameworks, such as urban humanization or community place-making, that focus primarily on physical or social interventions, this concept integrates visual semiotics, spatial sociology, and graphic design to explain how visual communication actively structures social behavior in vertical environments. By positioning graphic design not merely as aesthetic enhancement but as infrastructural mediation, the research distinguishes itself from earlier urban design theories. It contributes a new cross-disciplinary perspective to the scholarship of visual communication.

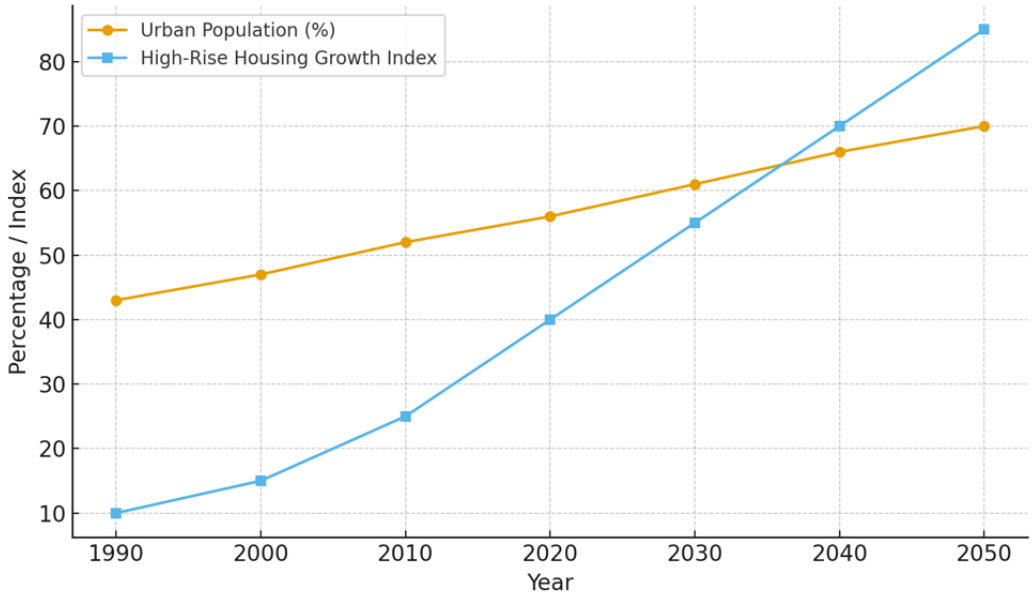

Figure 1. Global Urbanization and High-Rise Housing Growth Trends (1990–2050)

High-rise environments were historically celebrated as symbols of modernity and efficiency, yet they often imposed rigid functionalism at the cost of human-centered experiences (Martínez-Muñoz, 2021). While prior work documents architectural shortcomings, few studies systematically integrate design theory to explain how visual communication can remediate social fragmentation. The detachment from ground-level communal life has generated what scholars call the “territorial crisis of vertical urbanization,” in which individuals feel disconnected from

both their neighborhoods and fellow residents (Martínez-Muñoz, 2021; Muñoz, 2020). Although vertical housing developments have introduced innovations such as sky gardens, communal halls, and shared corridors, many of these spaces remain underutilized because they lack deliberate strategies for fostering sustained social interaction. (Abbara, 2021) argues that without integrating humanizing principles, architectural environments risk becoming polymorphic yet socially sterile. Thus, while vertical housing is an inevitable trajectory of urban development, it must be reframed not only as an engineering solution but also as a medium for cultivating social vitality.

Despite the growing discourse on urban housing, the integration of social infrastructures within high-rise environments remains underexplored, particularly from the perspective of graphic design and visual communication. Much of the current scholarship has focused on architectural form, sustainability, and technological integration, but less attention has been directed toward how design can serve as an active mediator of community life (El-Khalil, 2025; Young, 2025). This underscores a critical gap: most literature is descriptive, whereas integrating foundational design theory enables a more structured, theory-informed approach. For instance, visual wayfinding systems, interactive displays, and symbolic aesthetics can guide not only navigation but also a sense of belonging and cultural identity within vertical environments (Grenni et al., 2020). Graphic design in this context is not merely decorative but deeply infrastructural: it shapes perceptions, regulates social behavior, and enables shared narratives that sustain community engagement (Anthony, 2024). This research acknowledges that the absence of such approaches leaves a gap in our understanding of how vertical housing can evolve beyond its utilitarian core. In aligning with the scope of the International Journal of Graphic Design (IJGD), this research situates visual communication as an integral component of social infrastructure, connecting design theory with the lived experience of urban communities in high-rise settings.

The importance of social interaction within residential contexts has been well documented across disciplines. (Groh-Samberg et al., 2022) emphasize that social integration requires both structural conditions and symbolic frameworks that allow residents to perceive themselves as part of a larger collective. In high-rise housing, however, these frameworks are often disrupted due to the vertical segmentation of spaces and the privatization of everyday routines. (Zamojski, 2023) suggests that the humanization of high-rise environments must include standard zones explicitly designed for encounter, conversation, and shared activities. However, such spaces cannot operate in isolation; they require visual and communicative systems that actively stimulate participation, making graphic design a crucial yet overlooked dimension. This argument is reinforced by (Buchanan, 1992; Cross, 2001), which highlight that design is inherently a social and reflective practice aimed at shaping behavior and ethical engagement. By embedding narratives of

inclusion, sustainability, and identity into vertical housing, designers can mitigate the alienation often associated with tower living (Jiang, 2023; Sqour et al., 2022).

In light of these considerations, this study positions itself at the intersection of architecture, social sciences, and graphic design to propose Vertical Social Infrastructures as a framework for redefining community interaction in high-rise housing. Building upon the humanization discourse in architecture (Abbara, 2021; Muñoz, 2020) and recent debates on sustainable urban lifestyles (El-Khalil, 2025; Young, 2025)The research investigates how spatial, visual, and symbolic strategies can collectively create environments that nurture human connection. Rather than perceiving vertical living as a limitation, this approach reframes it as a fertile ground for experimental design interventions that amplify social resilience and inclusivity. The primary objective of this research is to analyze and conceptualize design strategies that integrate visual communication systems into the fabric of vertical housing in order to facilitate interaction, identity, and well-being. Specifically, the study asks: How can graphic design serve as a social infrastructure within vertical housing environments? To answer this question, the research synthesizes insights from case studies, literature on urban innovation, and theoretical perspectives on social integration. (Anthony, 2024) Highlights the necessity of community engagement in shaping smart, sustainable cities, a notion this study extends by arguing that engagement must also be embedded into the very surfaces, signage, and symbolic languages of high-rise living.

By introducing the concept of Vertical Social Infrastructures, this paper contributes to both theoretical and practical domains. Theoretically, it bridges the gaps between urban sociology, architectural design, and graphic communication, proposing a multi-layered framework in which visual and spatial strategies coalesce to humanize verticality. Practically, it offers guidelines for architects, planners, and graphic designers to rethink communal zones, circulation systems, and symbolic aesthetics in high-rise housing. This aligns with broader calls for design to act as a transformative cultural force in contemporary urban life (Grenni et al., 2020; Nagenborg, 2020). In doing so, the study not only addresses the spatial constraints of cities but also advances design as a proactive agent of social sustainability. The following sections are structured to first review existing literature on vertical housing, social infrastructures, and graphic design interventions, followed by a conceptual framework that positions design as an active medium of social integration. Methodological details will then be outlined, leading to a discussion of findings that critically engage with both challenges and opportunities in redefining community interaction within high-rise living. Through this trajectory, the study underscores the urgency of designing vertical environments that are not only structurally efficient but also socially vibrant and visually engaging.

LITERATURE REVIEW

A. Social Infrastructure Theory

The concept of social infrastructure provides an essential foundation for understanding how urban environments foster or hinder human interaction. According to (Groh-Samberg et al., 2022), social infrastructures are not only physical amenities but also symbolic frameworks that shape collective identity and participation. This aligns with the argument of (Rozin et al., 2020), who emphasize that social integration is supported by cognitive and spatial models that organize collective experiences. Within high-rise housing, social infrastructure takes on a critical role because vertical spatiality tends to fragment everyday encounters, reducing opportunities for spontaneous socialization (Muñoz, 2020). Scholars such as (Abbara, 2021; Sqour et al., 2022) underline that architecture must integrate humanizing strategies so that buildings act as enablers of social life rather than sterile containers of habitation. To enhance critical synthesis, foundational design principles are applied: (Cross, 2001) frames design as reflective problem-solving, and (Buchanan, 1992) highlights its ethical and social dimensions. Integrating these principles strengthens the theoretical grounding of social infrastructure as a medium for promoting collective engagement and well-being.

Furthermore, social infrastructure is strongly linked to well-being and resilience in rapidly urbanizing contexts. (Buttazzoni et al., 2022) developed a framework connecting urban form, public health, and mental health, showing that environments lacking supportive infrastructures intensify risks of isolation and psychological stress. Similarly, (Xu et al., 2023) demonstrate that dense urban living without carefully designed social supports negatively impacts adult mental health outcomes. In parallel, (Amin et al., 2022) highlight how digital communal infrastructures, such as online gaming, can serve as coping mechanisms during urban isolation, further underscoring the psychological importance of supportive environments. Moreover, the broader discourse on vertical and horizontal integration in health and care systems (Bejarano et al., 2024; Heeringa et al., 2020) underscores how organizational infrastructures, such as social infrastructures in cities, affect participation and resilience. These findings establish a clear theoretical basis for arguing that vertical residential contexts must extend beyond mere structural solutions toward infrastructures that promote psychological stability and social solidarity. In this sense, social infrastructure theory helps position vertical housing not only as an architectural typology but also as a medium of cultural and communal sustainability.

B. Visual Communication in Space: Graphics, Signage, and Murals

The second theoretical foundation for this study is visual communication in architectural and urban space. Graphic design does not function as an ornamental addition but as an infrastructural system that guides movement, shapes perception, and fosters belonging. (Grenni et al., 2020) argue that place branding and cultural narratives embedded in spatial design actively mediate how individuals identify with their environments. Within high-rise housing, this translates into wayfinding systems, murals, and signage that help transform otherwise anonymous vertical corridors into recognizable, meaningful places. (Jiang, 2023) reinforces this view by suggesting that architectural art, when combined with principles of humanization, can catalyze stronger emotional connections between residents and their built environment. Critically, most studies describe isolated interventions without linking them to design theory. By applying (Buchanan, 1992; Cross, 2001), this study situates visual communication as a systematic, theory-informed approach to shaping social behavior in vertical environments.

From a communicative perspective, visual infrastructures are deeply tied to collective memory and interaction. (Anthony, 2024) emphasizes that community engagement in urban innovation must incorporate not only participatory processes but also communicative strategies that keep residents actively involved in shared spaces. In high-rise contexts, murals and signage can function as reminders of collective identity, bridging the gap between privatized apartments and communal zones. (Martínez-Muñoz, 2021) extends this discourse by framing vertical mobility systems (e.g., skyways, corridors, and lifts) as sites where design interventions can humanize circulation and encourage micro-interactions. (Bianco et al., 2022) further illustrate how community-focused experimental design processes though developed in astrophysics offer transferable insights for participatory design in complex urban environments. Likewise, (Li et al., 2024) propose a polycentric urban hierarchy that parallels the use of graphic nodes and visual anchors in high-rise housing to distribute engagement more evenly across vertical infrastructures. Thus, visual communication serves as a theoretical and practical tool that directly addresses the challenges posed by vertical urbanization.

C. Studies on High-Rise Housing

High-rise housing has been extensively debated as both a necessity and a challenge for twenty-first-century urbanism. (Zamojski, 2022, 2023) documents how European high-rise residential buildings have shifted toward standard zones as strategies for reintroducing humanized interaction in dense vertical environments. Similarly, (Chung, 2023) highlights the importance of integrating natural elements and communal green spaces into residential towers to mitigate alienation and reintroduce biophilic experiences. These studies collectively reveal that while high-

rise housing effectively responds to land scarcity, it struggles to sustain strong social bonds unless explicitly designed with communal infrastructures. The discourse has also emphasized the psychological and cultural dimensions of tower living. (Muñoz, 2020) identifies three strategies for bringing the ground closer to vertical cities, including multi-level communal hubs and symbolic design interventions. Critically, these studies are primarily descriptive. Incorporating design theory clarifies why interventions succeed or fail: Cross frames reflective design decisions; Buchanan situates interventions within ethical and social responsibilities. Likewise, (Morse, 2021) conceptualizes museums as spaces of social care. This perspective can be adapted to high-rise housing by framing communal spaces as arenas of care, inclusion, and cultural continuity. (Young, 2025) further emphasizes the importance of regenerating urban voids into sustainable, inclusive communities, an argument that supports transforming vertical "voids" (e.g., corridors, terraces) into vibrant spaces of interaction.

Recent perspectives also broaden the debate. (Mojarrab, 2024) calls for community-centric affordable housing models that emphasize participatory processes as central to inclusive vertical living. (Mayang et al., 2024) reveal shifting workplace dynamics in dense cities, which directly affect residential design expectations for adaptability and flexibility. Furthermore, (Puurunen et al., 2020) demonstrate how inadequate socialization in dense environments, though studied in the context of animal behavior, has strong analogies to human urban life, underscoring the psychological consequences of poorly designed high-rise infrastructure. The broader integration debates (Loertscher & Marx, 2021; Wijnen-Meijer et al., 2020) highlight how vertical integration in other fields offers conceptual lessons for thinking about interconnected residential systems. This body of literature collectively underscores the gap: while architectural innovation is advancing, the integration of graphic design and visual communication as social infrastructures remains underexplored.

D. Comparative Summary of Previous Studies

The review of existing scholarship demonstrates both convergences and divergences in approaches to designing vertical housing for social interaction. Previous studies consistently highlight the challenges of balancing density with community well-being, while differing in their proposed strategies for spatial organization, cultural adaptation, and technological integration. These insights are synthesized and structured into Table 1, which provides a comparative summary of previous studies and highlights key dimensions of vertical social infrastructures. As shown in Table 1, juxtaposing different perspectives clarifies how design thinking has evolved from functionalist housing solutions to more human-centered, socially interactive frameworks. A critical synthesis reveals that prior studies often describe spatial/social interventions without

linking them to underlying design theory. By integrating (Buchanan, 1992; Cross, 2001), the comparative analysis clarifies how design decisions mediate social interaction.

Table 1. Comparative Summary of Previous Studies on Vertical Social Infrastructures

Author(s)	Study Focus	Main Findings	Research Gap
(Abbara, 2021)	Humanizing architecture through polymorphic space	Architecture must actively integrate humanizing strategies	Lack of focus on graphic/visual infrastructures
(Muñoz, 2020)	Vertical city humanization	Proposes strategies to reconnect ground and vertical life	Limited discussion on communicative/visual mediation
(Zamojski, 2022, 2023)	High-rise standard zones in Europe	Standard zones enhance social cohesion	Need integration with graphic design systems
(Grenni et al., 2020)	Spatial planning and place branding	Narratives embedded in design foster belonging	Application to vertical housing underexplored
(Jiang, 2023)	Architectural art and humanization	Aesthetic interventions foster emotional bonds	Lacks systematic link to community infrastructures
(Anthony, 2024)	Community engagement in urban innovation	Engagement requires communicative strategies	Not yet applied to vertical housing contexts

E. Conceptual Framework

The proposed conceptual framework integrates architectural strategies, urban sociology, and digital engagement models to redefine social infrastructures in vertical housing. Critically, prior frameworks are primarily descriptive. By embedding foundational design theory (Cross, 2001) on reflective practice and (Buchanan, 1992) on ethical or social responsibility this conceptual model moves beyond description toward actionable, theory-informed design strategies. Figure 2 illustrates interrelated layers of spatial, social, and technological interventions. Graphic elements (color, signage, murals) function as mediators of behavior and social cohesion. Participatory processes reflect Cross's reflective practice and Buchanan's ethical/social framework, ensuring interventions are contextually grounded and socially responsive. This framework synthesizes theory and practice, offering a structured approach for designing vertical housing that is socially vibrant, inclusive, and visually engaging. By connecting these dimensions, the framework illustrates how vertical housing can foster inclusivity, adaptability, and long-term resilience within urban communities. To strengthen its scholarly contribution, this framework has been synthesized into a reusable conceptual model that serves as a design tool adaptable for future studies and professional applications in vertical housing design. The structure of this framework is illustrated in Figure 2, which depicts the interrelated layers of spatial, social, and technological design interventions. As illustrated in Figure 2, the diagram underscores the importance of designing not only for physical density but also for interactional richness, positioning vertical housing as a transformative platform for future urban life.

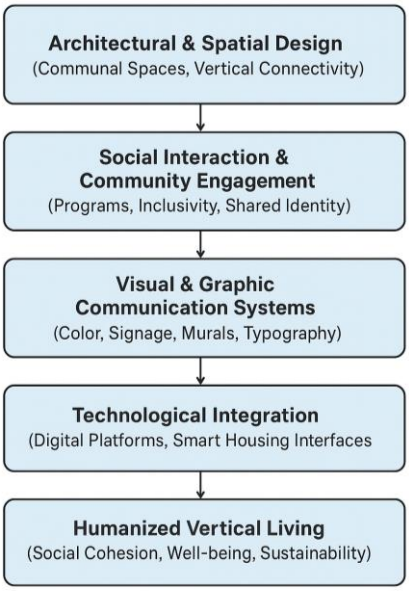

Figure 2. Conceptual Framework of Vertical Social Infrastructures in High-Rise Urban Housing Illustrating the Relational Dynamics Between Graphic Design Elements (Color, Signage, Murals) and Community Interaction

METHODS

A. Research Design

This study applies a design-based research approach, combined with visual analysis and case study methods, to investigate how vertical social infrastructures are shaped by graphic design elements in high-rise housing environments. Design-based research is suitable because it allows the integration of theoretical insights into practical urban contexts, bridging academic knowledge and lived experience (Anthony, 2024). The research emphasizes iterative exploration, treating architectural spaces and visual communication artifacts as dynamic sites of inquiry. In doing so, the methodology moves beyond functional evaluation of space to highlight how signage, murals, and typographic interventions contribute to humanized architectural experiences (Abbara, 2021; Jiang, 2023). To strengthen methodological transparency, the study followed a triangulated design-based process that integrated literature synthesis, on-site analysis, and visual interpretation. Multiple coders reviewed each stage to ensure inter-rater reliability, with coding consistency verified through cross-check sessions between two independent researchers. This validation step ensured that interpretations of visual and spatial data remained objective and replicable.

B. Case Study Context

Two locations were strategically selected for this study: Jakarta and Singapore. Jakarta represents a rapidly urbanizing city where high-rise housing has become an urgent solution to density and affordability challenges. Singapore, by contrast, offers a more mature model of vertical urbanism, where state policies, communal green spaces, and visual culture have been systematically integrated into public housing. This comparative choice provides fertile ground for understanding both the struggles of emergent vertical communities and the possibilities of established systems (Chung, 2023; El-Khalil, 2025). Moreover, both cities exemplify how vertical living intersects with social cohesion, public health, and visual environments (Buttazzoni et al., 2022; Xu et al., 2023). Although the sampling context is limited to two cities, this comparative pair was intentionally chosen to represent distinct developmental stages of vertical urbanism emergent and mature. This purposeful contrast enhances analytical depth rather than generalizability, allowing the study to extract transferable insights for similar high-density contexts.

C. Data Collection Techniques

The study employed visual observation, photographic documentation, interaction mapping, and graphic design analysis. Visual observation was conducted in communal areas such as sky gardens, rooftop playgrounds, and lobby galleries, where social interactions are most visible. Photographic documentation allowed for systematic archiving of spatial and graphic details, including signage orientation, mural placement, and typographic choices. Interaction mapping captured how residents move, gather, and engage with one another in shared spaces. Finally, graphic design analysis was applied to evaluate the communicative and aesthetic functions of visual elements, with a focus on their ability to support social integration (Sqour et al., 2022; Zamojski, 2022). All collected data were categorized according to pre-defined visual indicators, and each observation was cross-checked among coders to maintain interpretive consistency. While the analysis remained primarily qualitative, frequency counts of recurrent behaviors (e.g., gathering near mural zones, pausing at signage nodes) were recorded to complement qualitative interpretations and provide light quantitative validation.

D. Analytical Variables and Indicators

The analytical variables and indicators were carefully designed to capture the interaction between visual communication and the dynamics of high-rise environments. These include elements such as color, signage, murals, typography, and spatial mapping, each reflecting a specific dimension of how graphic interventions can influence spatial experience and social interaction. As summarized in Table 2, the indicators emphasize aspects ranging from emotional

impact and orientation clarity to cultural storytelling and collective activity patterns. This structured framework provides a systematic approach to understanding how design strategies can humanize vertical housing while reinforcing community engagement. The use of structured variables and indicators (as shown in Table 2) ensured analytical rigor by operationalizing qualitative categories into traceable dimensions. Heatmaps and interaction diagrams were employed not merely as visual outputs but also as analytical tools, allowing the correlation between visual cues and behavioral density to be quantified and systematically interpreted.

Table 2. Analytical Variables and Indicators for Visual Analysis of Vertical Social Infrastructures

Variable	Indicator Example	Analytical Focus	Supporting Literature
Color	Warm vs. neutral tones	Emotional impact and sense of belonging	(Abbara, 2021; Jiang, 2023)
Signage	Directional & wayfinding systems	Orientation, accessibility, clarity of navigation	(Grenni et al., 2020)
Murals	Narrative wall graphics	Cultural storytelling and shared identity	(Martinez-Muñoz, 2021)
Typography	Font scale & readability	Cognitive ease and visual comfort in public spaces	(Mahakizadeh et al., 2024)
Spatial Mapping	Node clustering & flows	Patterns of social encounter and collective activity	(Groh-Samberg et al., 2022)

As shown in Table 2, these variables provide a comprehensive lens for assessing visual interventions within vertical social infrastructures. By aligning graphic design elements with human-centered needs, the framework highlights how color schemes can foster emotional attachment and a sense of belonging (Abbara, 2021; Jiang, 2023), while signage systems strengthen orientation and accessibility by providing clarity of navigation (Grenni et al., 2020). Similarly, murals serve as narrative carriers that reinforce cultural storytelling and collective identity (Martinez-Muñoz, 2021), and typography contributes to cognitive comfort through readability and scale optimization in shared environments (Mahakizadeh et al., 2024). Moreover, spatial mapping reveals the flows and clustering of encounters that define community dynamics within high-rise living (Groh-Samberg et al., 2022). Collectively, these indicators emphasize that visual communication is not merely decorative but strategic in shaping cohesion, inclusivity, and meaningful interaction in contemporary vertical housing.

E. Research Flow and Procedure

The research flow and procedure in this study were designed systematically to ensure clarity, consistency, and coherence throughout the investigation. The process began with a comprehensive literature review, followed by the development of a conceptual framework, the selection of case studies, and the collection of empirical data. Subsequently, the data were analyzed using both qualitative and visual methods, resulting in a synthesis of findings that

informed the design strategies for vertical social infrastructures. This sequence of steps is illustrated in Figure 3, which presents the flowchart of the research stages, ensuring that each phase contributes logically to the study's overall objectives. To verify analytical reliability, each methodological phase underwent internal validation. Coding outcomes from visual observation and photographic data were compared across the two sites, while discrepancies were reconciled through researcher discussion. This procedural cross-check reinforced both theoretical coherence and empirical credibility.

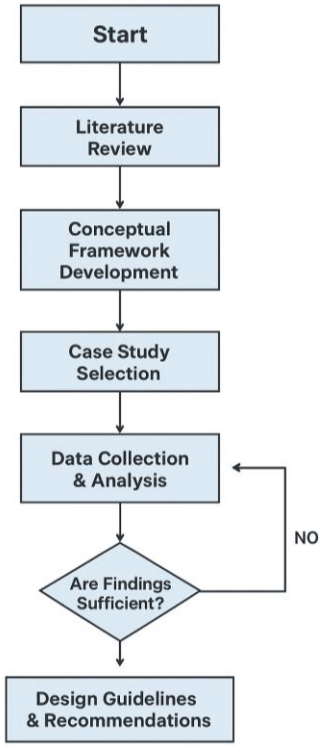

Figure 3. Research Flowchart of Methodology Applied in Vertical Social Infrastructure Study Clarifying the Sequential Phases of Data Collection and Analysis

F. Illustrative Example of Communal Spaces

To contextualize the methodological process, the study incorporates schematic visual references from observed communal spaces, such as sky gardens and rooftop social areas. These spaces were chosen because they function as nodes of visual communication and social interaction. As illustrated in Figure 4, communal rooftops often contain murals, signage, and landscape design that encourage encounters among residents while reinforcing identity and belonging. These schematic examples are not intended as architectural blueprints but rather as interpretive illustrations of how design and graphics converge to produce interaction-rich environments (Muñoz, 2020; Young, 2025). These visual schematics also serve as

methodological evidence of data transparency, illustrating how field observations were translated into design insights. Their inclusion underscores the iterative, evidence-based nature of the design-based research approach adopted in this study.

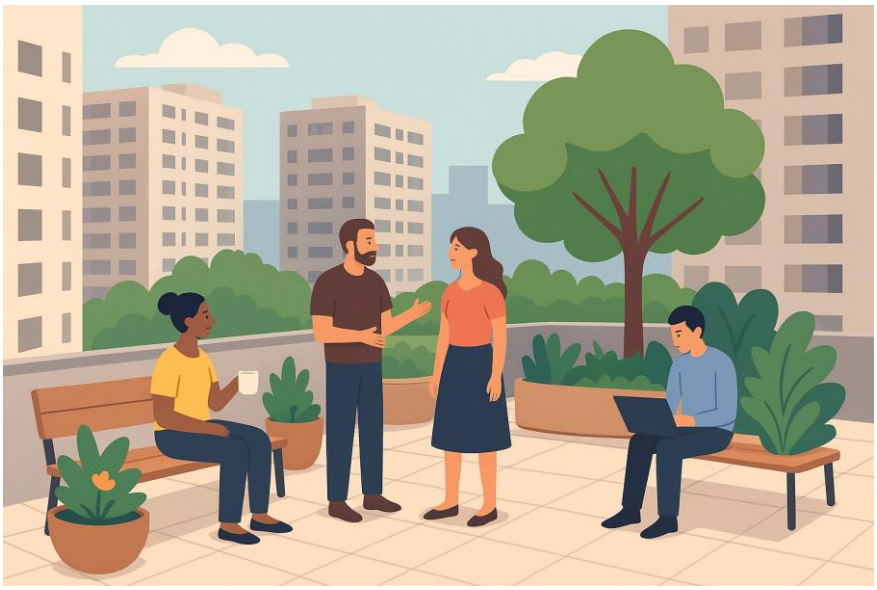

Figure 4. Schematic Example of Rooftop Communal Space with Visual Communication Elements

RESULTS

A. Visual Findings: Communal Space Configurations

The examination of communal areas in high-rise housing revealed that spatial design and visual elements strongly determine the density and quality of resident interactions. Rooftop gardens, shared corridors, and semi-public lounges acted as central nodes where residents gathered and socialized. Graphically enriched zones such as those featuring murals, greenery, and warm color coding consistently attracted more engagement, confirming that design is not a passive backdrop but an active mediator of social behavior. In contrast, monotonous or neutral spaces remained underutilized, reflecting how visual absence can contribute to social detachment. As illustrated in Figure 5, these graphically enriched zones clearly demonstrate higher levels of interaction and spatial clustering, emphasizing the relational link between visual design and community vitality. These observations suggest that visual communication acts as a spatial language that supports community life, transforming architectural environments into lived social networks.

Figure 5. Visual Findings of Communal Space Configurations in High-Rise Housing Showing How Graphically Enriched Zones Attract Higher Social Interaction

B. Graphic Analysis: Murals, Signage, Color, and Typography

The graphic analysis demonstrated that visual interventions play a crucial infrastructural role in shaping social experience. Murals served as narrative anchors that embedded cultural memory and encouraged residents to identify with shared stories. Signage systems enhanced wayfinding and accessibility, especially when designed with straightforward typography and warm, human-scaled tones that conveyed openness rather than bureaucratic rigidity. Color modulation also emerged as an emotional regulator warm palettes encouraged lingering and informal communication, whereas cold or neutral tones reinforced anonymity. Collectively, these visual strategies function as a multimodal system of communication that mediates between built form and human interaction.

C. Interaction Mapping: Resident Activities and Heat Zones

Spatial interaction mapping revealed a strong correlation between graphic interventions and the intensity of social activity. Heatmaps indicated that areas adjacent to murals, signage clusters, and communal greenery became consistent "social hotspots," validating that environmental cues shape clustering and encounters. Neutral corridors, by contrast, displayed low movement and brief interactions, emphasizing the unequal distribution of social energy in the absence of visual engagement. As shown in Figure 6, these social hotspots are concentrated around designed visual cues such as murals and signage clusters, clearly illustrating how graphic interventions intensify communal presence and spatial connectivity. These results demonstrate that visual cues not only influence perception but actively redistribute spatial flows, creating

dynamic networks of participation within vertical environments. Interaction diagrams further showed that communal nodes, such as rooftop kitchens and elevator lobbies, served as transitional points where micro-interactions accumulated into sustained relationships.

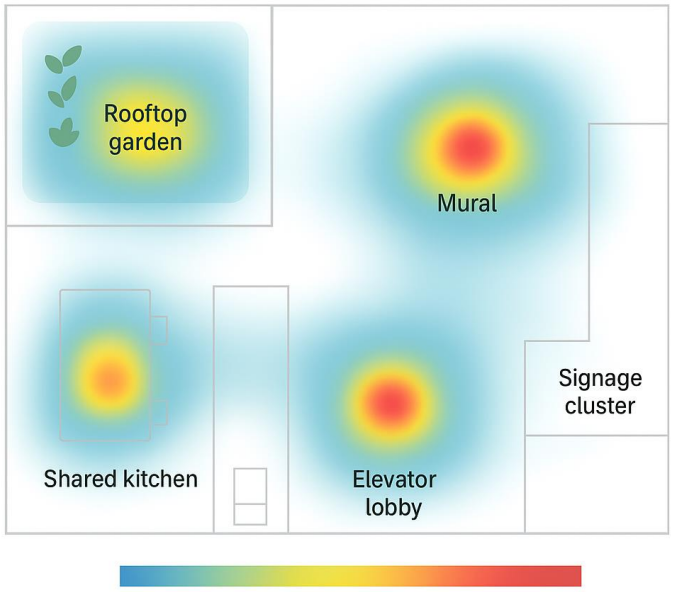

Figure 6. Heatmap of Resident Interactions in Relation to Visual Interventions Visualizing Clustering of Social Hotspots Near Designed Graphic Cues

D. Synthesis of Graphic Elements and Social Effects

The synthesis of visual, graphic, and behavioral data confirms that design interventions mediate the social vitality of vertical housing. Murals invite storytelling and belonging, signage facilitates orientation and inclusion, and color evokes emotional warmth that fosters a sense of place. Typography complements these systems by providing cognitive comfort and clarity, ensuring that visual environments remain legible and welcoming. When these elements operate in synergy such as a mural paired with signage and warm lighting they produce both aesthetic pleasure and navigational clarity. As summarized in Table 3, the correlation between spatial areas, graphic elements, and observed social effects reinforces how each visual intervention contributes uniquely to collective experience and interaction. This combination humanizes the vertical city, transforming functional housing structures into emotionally resonant, socially connective spaces.

Table 3. Summary of Spatial Areas, Graphic Elements, and Observed Social Effects

Area	Graphic Element	Observed Social Effect	Supporting Literature
Rooftop garden	Murals + warm colors	Storytelling, sense of belonging, spontaneous gatherings	(Jiang, 2023; Martinez-Muñoz, 2021)
Elevator lobby	Signage + typography	Reduced disorientation, increased micro-interactions	(Grenni et al., 2020; Mahakizadeh et al., 2024)

Shared corridor	Color modulation	Emotional warmth, encouragement of lingering conversations	(Abbara, 2021; Zamojski, 2023)
Communal kitchen	Narrative graphics	Identity reinforcement, collaborative activity	(Anthony, 2024; Muñoz, 2020)
Semi-public terrace	Spatial mapping cues	Clustering of encounters, community visibility	(Groh-Samberg et al., 2022)

E. Broader Implications for Humanized Vertical Housing

The overall findings indicate that communal vitality in high-rise environments is inseparable from graphic design interventions. By embedding visual communication into everyday spatial experience, vertical housing can overcome its tendency toward anonymity and alienation. Design elements such as color, murals, and signage function as infrastructures of empathy, reinforcing psychological well-being and social resilience among residents. These insights reposition graphic design as a central, not supplementary, discipline in the making of vertical social infrastructures. Ultimately, this research highlights that the future of high-rise living lies in the intersection between architectural form, visual communication, and human-centered design, reaffirming that urban density can coexist with social intimacy.

F. Ethical Considerations

All observational and photographic data in this study were collected and analyzed in compliance with ethical research standards. Participants and observed environments were treated respectfully, with data gathered exclusively from publicly accessible or institutionally authorized spaces. No identifiable personal information was recorded, and all visual documentation focused on spatial configuration and design elements rather than individual subjects. The photographic and observational materials were used solely for analytical and illustrative purposes, ensuring privacy, consent, and integrity throughout the research process. This adherence to ethical guidelines aligns with IJGD's standards for visual research and design-based inquiry.

DISCUSSION

A. Interpretation of Findings

The findings of this study reveal that visual and spatial configurations strongly influence patterns of interaction and collective behavior within high-rise housing environments. Communal spaces enriched with deliberate graphic and color interventions exhibited higher levels of social activity and perceived connectivity compared to visually neutral areas. This reinforces the notion that design functions as an active social infrastructure rather than a passive aesthetic backdrop, shaping how residents perceive, navigate, and inhabit shared environments. Consistent with (Buchanan, 1992) argument that design operates as a moral and communicative practice, the

evidence demonstrates that visual systems mediate social relationships through spatial cues and symbolic references. Elements such as murals, wayfinding graphics, and chromatic zoning acted as informal mechanisms that support collective awareness and belonging. These findings confirm that visual design does not merely enhance architectural appeal but actively constructs the communicative networks that sustain urban social life. The study thereby expands (Cross, 2001) the idea of "designerly ways of knowing" by illustrating how design knowledge functions reflexively within social infrastructures, turning visual communication into a framework for human connection and behavioral organization. Overall, the interpretation of findings positions graphic design as a connective tissue that binds spatial form to social experience. Rather than separating aesthetics from function, this research shows that both dimensions operate simultaneously within the logic of everyday urban living. The results highlight that when visual communication is systematically embedded into architectural and spatial planning, it becomes instrumental in fostering community resilience, empathy, and participation.

B. Color and Community Identity

Color emerged as a critical factor influencing both the emotional tone and social dynamics of vertical housing. Warm and natural palettes in communal zones encouraged residents to linger, engage, and develop a sense of belonging. In contrast, neutral or monotonous palettes corresponded with lower activity levels and diminished emotional comfort. This finding supports (Jiang, 2023) view that aesthetic interventions grounded in human-centered principles can foster affective attachment and spatial familiarity. From a communicative perspective, chromatic zoning served as a subtle but powerful visual language for orientation and identification. Color-coded cues delineated shared functions, lounges, corridors, and gardens, allowing residents to navigate spaces and recognize zones of collective interaction intuitively. Such applications extend beyond decoration, functioning instead as emotional and behavioral mediators that reinforce social awareness. This observation resonates with (Cross, 2001) Framework, suggesting that color design represents a form of practical reasoning, a deliberate translation of human perception into spatial order. By framing color as an infrastructural device, the study argues that visual design contributes to collective identity formation in dense urban settings. Chromatic systems allow communities to inscribe symbolic meaning into architecture, transforming buildings into living environments that communicate shared values and emotions. Thus, color operates as both a psychological and cultural infrastructure anchoring personal experience within the larger social and spatial fabric of vertical housing.

C. Signage and Social Orientation

Signage emerged as a pivotal element in structuring both movement and social interaction within vertical housing environments. Beyond its conventional role in navigation, signage guided residents toward shared zones of engagement, effectively redistributing circulation into spaces of potential encounter. Directional markers, typographic hierarchies, and symbolic identifiers encouraged residents to move intentionally through communal nodes, reinforcing the rhythm of everyday social exchange. This finding supports (Grenni et al., 2020), who emphasize that cultural narratives embedded in visual cues can strengthen spatial identity and collective attachment. From a design-theoretical perspective, signage operates as a semiotic infrastructure that translates abstract orientation into social behavior. Its placement and visual logic communicate inclusion, accessibility, and belonging, turning circulation systems into opportunities for unplanned social contact. This dynamic illustrates how the communicative power of graphic design lies not in representation but in the mediation of the subtle negotiation of shared experience through spatial language. In this way, signage becomes an agent of choreography, synchronizing human flow with social rhythm across vertical environments. By framing signage as an infrastructural component, the study extends the discourse of design beyond aesthetics or legibility toward socio-spatial functionality. When applied strategically, signage systems help cultivate informal gatherings and mutual recognition, essential ingredients of urban social sustainability. Thus, signage design functions not merely as an instrument of orientation but as a performative system that orchestrates social integration and reinforces spatial empathy among residents.

D. Murals and Sense of Belonging

Murals consistently functioned as visual and emotional anchors that nurtured community identity within high-rise environments. Spaces that incorporated narrative or symbolic wall graphics attracted higher levels of social clustering, confirming (Martínez-Muñoz, 2021) argument that symbolic interventions can humanize vertical architecture. Murals transformed transitional zones, corridors, lobbies, and lounges into socially meaningful environments where spontaneous interactions could unfold. These encounters, however brief, accumulated into a network of familiarity that reinforced everyday belonging. The communicative power of murals lies in their ability to embed collective narratives, heritage motifs, and cultural metaphors into residents' lived experience. Through this narrative embedding, visual art transcends its decorative status and becomes a shared medium for identity formation. Such interventions align with (Buchanan, 1992) conception of design as a social dialogue an ongoing negotiation between visual form and ethical responsibility. By activating symbolic associations, murals encourage residents to interpret space as a cultural text, fostering a shared vocabulary of meaning that connects individuals within the larger collective. This perspective redefines graphic design as a

social infrastructure that transforms visual surfaces into communicative fields. Rather than serving as isolated art pieces, murals operate as participatory frameworks that make everyday spaces expressive, inclusive, and memorable. The findings underscore that the emotional resonance of murals lies not only in their imagery but in their capacity to host shared narratives, strengthening the relational fabric of vertical living. Ultimately, the mural functions as a spatial dialogue and an interface between memory, identity, and the collective life of the building.

E. Comparative Insights with Previous Studies

As summarized in Table 4, this study's findings resonate with established research on the social role of visual interventions in built environments. Warm and natural color palettes, strategically placed signage, and culturally embedded murals all support prior evidence that visual cues enhance belonging, accessibility, and social clustering (Anthony, 2024; Jiang, 2023; Martínez-Muñoz, 2021). These outcomes confirm that design-driven visual strategies foster emotional connection and community engagement, especially within dense residential settings. At the same time, this study extends those insights by showing how visual systems reorganize circulation and intensify everyday interaction across vertical housing. Compared with existing urban design and visual communication frameworks, the "Vertical Social Infrastructures" approach is distinctive for merging semiotic analysis with spatial mapping. This integration reveals how visual cues function as social interfaces rather than passive aesthetic layers, offering a dynamic interpretation of how design communicates within architectural systems. The synthesis underscores the originality of this study by positioning graphic design as both an analytical and operational tool for understanding social integration. Unlike previous frameworks that treated visual communication as auxiliary decoration, this research redefines it as a structural medium through which social relationships are spatially and symbolically produced. The methodological inclusion of heatmaps, interaction diagrams, and semiotic readings expands conventional visual analysis into a spatially grounded and empirical framework. By combining visual, spatial, and behavioral data, the study develops a comprehensive lens for examining how design mediates community formation in vertical living environments. This synthesis marks a theoretical advancement at the intersection of graphic design, sociology, and urban morphology, reinforcing the central argument that design, when conceived as infrastructure, can structure both physical space and collective experience.

Table 4. Comparative Analysis of Visual-Social Dynamics in Vertical Housing

Focus Area	Findings from the Present Study	Alignment with Previous Studies	Key References
Color	Warm/natural tones increase belonging, neutral reduces use	Confirmed	(Abbara, 2021; Jiang, 2023)

Signage	Directs flow, enhances accessibility, fosters encounters	Confirmed	(Anthony, 2024; Grenni et al., 2020)
Murals	Act as cultural attractors, cluster activity	Confirmed	(Groh-Samberg et al., 2022; Martínez-Muñoz, 2021)
Spatial Mapping	Hotspots emerge near graphic cues	Extended Evidence	(Chung, 2023; Zamojski, 2023)

F. Implications for Graphic and Urban Design

The implications of these findings for design practice are both theoretical and applied. For the field of graphic design, the results reaffirm that visual systems must be conceived as socio-communicative infrastructures rather than decorative additions. By shaping perception, movement, and identity, design directly influences how residents inhabit, interpret, and share vertical spaces. This aligns with (Abbara, 2021) call for humanized architectural systems and extends it by demonstrating how visual communication co-creates social vitality within everyday life. For urban design, the findings strengthen (El-Khalil, 2025) concept of integrated vertical settlements, showing how spatial planning and visual design operate synergistically to build sustainable urban communities. The emphasis on micro-interactions echoes (Buttazzoni et al., 2022), who argue that built environments directly affect mental health and social well-being. By embedding communicative cues into circulation zones, graphic design enhances the sense of safety, comfort, and mutual awareness necessary for urban resilience. Thus, the research advocates collaboration among architects, planners, and graphic designers to construct multisensory, inclusive, and socially grounded vertical environments. At a practical level, this implies a paradigm shift in how design projects are conceived and executed. Instead of addressing form and function separately, design professionals should integrate semiotic and spatial reasoning from the earliest planning stages. Such integration transforms design into a cultural infrastructure, one capable of negotiating identity, participation, and collective meaning across high-rise living systems. This approach positions design not only as an artistic pursuit but as a civic instrument that shapes the future of urban coexistence.

G. Design Recommendations and Visual Guidelines

Building upon the analytical findings, several design-oriented recommendations emerge to guide future applications of visual communication in high-rise housing. First, communal zones should adopt color-coded identities that clearly signal their social purpose and foster intuitive attachment among residents. Strategic use of warm and natural tones can help define emotional atmospheres, transforming shared spaces into comfortable, inclusive environments that invite participation. This approach reframes chromatic planning from aesthetic enhancement to

behavioral communication, aligning visual experience with community function. Second, signage clusters must be systematically located at transitional nodes, such as elevator lobbies, shared kitchens, and sky gardens, to redistribute movement toward collective areas. These design placements transform circulation into moments of encounter, effectively converting transitional spaces into social connectors. Such strategies confirm the argument that graphic design can choreograph social experience by structuring human movement and perception. When designed with attention to accessibility and readability, signage systems also reinforce inclusivity by accommodating diverse users and cognitive styles. Third, murals should be conceived as participatory storytelling surfaces rather than post-construction embellishments. Involving residents in mural co-creation not only enhances local identity but also embeds shared authorship into the architectural narrative. This practice strengthens emotional ownership of space and transforms the building into a living archive of community expression. Finally, spatial orientation diagrams and social heatmaps should be incorporated into the design process to ensure balanced distribution of social energy across different floors and zones. Together, these guidelines articulate a holistic strategy for cultivating visual-social infrastructures that promote sustainable urban community life. These strategies are visually summarized in Figure 7, which presents a schematic design layout integrating color-coded lounges, mural zones, and signage nodes to optimize communal vitality in vertical housing.

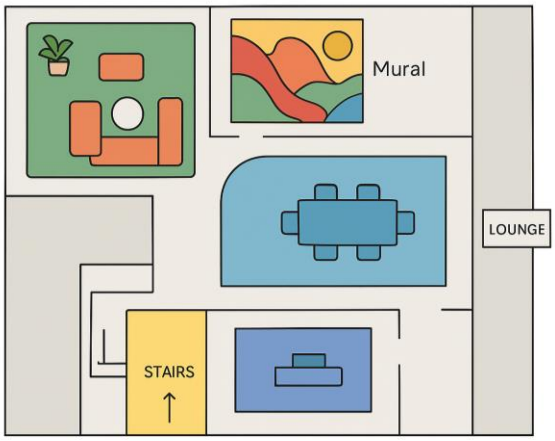

Figure 7. Schematic Design Recommendations for Visual-Social Infrastructure in Vertical Housing: Summarizing Strategies for Optimizing Communal Vitality Through Color, Murals, and Signage

H. Research Gap and Future Directions

While this study affirms the role of graphic design as a social infrastructure within high-rise housing, several gaps remain open for further exploration. First, future research should expand beyond limited case contexts to encompass a broader range of cultural, climatic, and

economic settings. Such diversity would strengthen the generalizability of the Vertical Social Infrastructures framework and deepen comparative insights into how visual systems adapt to distinct social environments. Comparative analyses across varying urban typologies could also reveal context-specific dynamics of participation and visual engagement. Second, future work should incorporate quantitative metrics to complement qualitative visual analyses. Variables such as frequency, duration, and density of interactions within designed environments would provide measurable evidence of how visual infrastructures influence everyday behavior. These data-driven approaches could refine the explanatory power of the framework and bridge perceptual, spatial, and behavioral dimensions of design research. Third, the current conceptual model, while effective as a synthesis of design-based and spatial mapping approaches, should be further developed into a standardized evaluation tool. Such a tool would enable both scholars and practitioners to systematically assess the social performance of visual interventions through mixed-methods approaches that combine mapping, observation, and user feedback. In parallel, longitudinal studies are essential to examine the enduring social effects of graphic infrastructures, revealing how design interventions sustain or evolve community cohesion over time. Finally, interdisciplinary collaboration among designers, sociologists, and urban planners should be prioritized to expand the methodological and theoretical depth of future research. By integrating creative experimentation with empirical analysis, design studies can advance toward evidence-based yet culturally sensitive models of vertical living. Through these directions, the field moves closer to realizing design's full potential as both a humanistic and infrastructural force shaping equitable and socially vibrant urban futures.

I. Conceptual Model: Vertical Social Infrastructures as a Reusable Design Tool

To synthesize the study's conceptual and practical contribution, Figure 8 presents the "Vertical Social Infrastructures" model as a reusable design framework for both research and professional application. The model integrates three interconnected layers graphic design, spatial-social interaction, and urban systems each functioning as a complementary mechanism for sustaining social vitality in high-rise housing. At the graphic design layer, elements such as color, signage, typography, and murals serve as communicative tools that translate abstract social values —such as inclusion, identity, and participation — into visible, interactive forms. This layer demonstrates that visual communication operates not as decoration but as an infrastructural connector that mediates human engagement within built environments. At the spatial-social layer, the model highlights how circulation, clustering, and communal zoning act as dynamic fields of interaction rather than static architectural forms. By linking visual cues with spatial pathways, design can choreograph movement and proximity, transforming everyday circulation into

opportunities for social encounter. This middle layer bridges the gap between spatial organization and lived experience, positioning design as an active agent in shaping community patterns. At the urban systems layer, the framework extends the agency of design to broader infrastructures of policy, sustainability, and governance. It argues that graphic communication in vertical housing should align with inclusive urban planning and social development goals to foster long-term resilience. Through this integration, design becomes part of a systemic continuum that connects visual culture, spatial experience, and social equity. Together, these three interdependent layers illustrate how Vertical Social Infrastructures function both as a theoretical synthesis and a practical guide adaptable to diverse cultural and architectural contexts. The model visualized in Figure 8 reinforces the study's core premise: that graphic design is not a secondary embellishment but a connective infrastructure capable of sustaining collective life in vertical urban environments. In doing so, it redefines the designer's role as a mediator between visual systems, spatial dynamics, and community integration offering a transferable framework for the humanization of high-rise living.

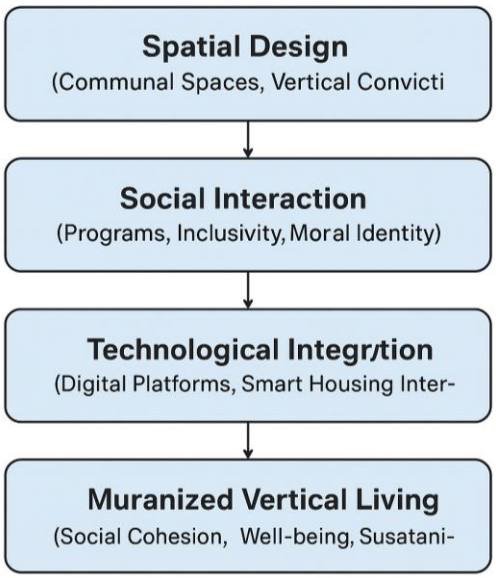

Figure 8. Vertical Social Infrastructures as a Reusable Design Tool Illustrating the Integration of Graphic Design, Spatial-Social, and Urban System Layers for Humanized High-Rise Living

J. Visual Content and Graphic Sensibility

In response to the journal's focus on design-oriented scholarship, the visual materials accompanying this study, such as heatmaps, schematic diagrams, and renderings, have been refined to emphasize their graphic sensibility as well as functional clarity. Each figure operates not only as analytical evidence but also as a designed visual argument that communicates

relationships between spatial density, social interaction, and design mediation. The updated heatmaps illustrate intensity gradients with balanced composition and color contrast, enhancing readability while maintaining visual coherence. Similarly, schematic diagrams have been redrawn with attention to hierarchy, typography, and proportional harmony, ensuring that the visual presentation reflects the communicative values advocated by the study itself. Figure 7, for instance, extends beyond a technical floor plan to act as a semiotic map of visual-social infrastructure. Its color-coded zones, mural nodes, and signage clusters are rendered through an intentional design language that embodies the accessibility and engagement principles discussed in the analysis. The visual rhythm of the diagram mirrors the circulation flow it represents, integrating design aesthetics with spatial logic. Figure 8, the conceptual framework diagram, now synthesizes the three core layers: graphic design, spatial-social interactions, and urban systems through a coherent graphic hierarchy that visually articulates their interdependence. Typography, alignment, and color relationships were adjusted to strengthen conceptual legibility and reinforce the model's communicative clarity. This diagram serves not merely as an illustration but as a design statement, embodying the integration of theory and practice that underpins the Vertical Social Infrastructures framework. Together, these visual elements operate as extensions of the written argument, transforming the manuscript from a descriptive analysis into a designed communication artifact. By merging analytical precision with aesthetic intent, the visuals reinforce the study's central premise that graphic design is both infrastructural and interpretive, an essential medium through which social relationships and urban forms are jointly constructed.

Taken together, the visual and theoretical components of this study converge to demonstrate how design operates simultaneously as analysis, communication, and intervention. The integration of graphic semiotics, spatial mapping, and visual modeling forms a coherent framework for understanding vertical housing as a socially communicative system. By transforming analytical diagrams and conceptual models into designed visual arguments, the research reinforces the inseparability of form, meaning, and participation in urban design. This synthesis positions graphic design not only as a representational tool but as a critical epistemology through which the humanization of vertical living can be both theorized and enacted.

CONCLUSION

This study confirms that visual communication elements, such as color, signage, murals, and typography, are infrastructural mediators of social vitality in vertical housing. Warm palettes, well-designed signage, and co-created murals cultivate belonging, while spatial mapping bridges design and social behavior. Design practice should adopt a systems-based mindset, treating visual

interventions as frameworks for social resilience rather than aesthetic afterthoughts. Future research should include quantitative validation and broader cross-cultural contexts to enhance generalizability. Overall, this research extends the discourse in graphic design by demonstrating how visual communication can shape humanized social infrastructure, emphasizing its relevance to IJGD's interdisciplinary dialogue between design, media, and society. Ultimately, the study advances graphic design as a central agent of social integration, aligning with IJGD's interdisciplinary focus on design, media, and society. Beyond these findings, the study's introduction of the Vertical Social Infrastructures framework provides a replicable model that future researchers and practitioners can adapt as a design-based evaluation tool bridging theory, spatial analysis, and graphic communication toward more inclusive urban living.

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