ARCHITECTURAL NUDGING FOR NCD PREVENTION IN COMMERCIAL SPACES

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ABSTRACT
Non-communicable diseases (NCDs) are strongly associated with modifiable behavioural risk factors, including physical inactivity and unhealthy diets. Although these behaviours are influenced by individual circumstances, they also occur within physical environments that structure everyday opportunities for movement, food choice, rest, and social interaction. Commercial spaces are particularly relevant because these activities frequently coexist within interconnected architectural settings. However, behavioural research on choice architecture and architectural research on health-supportive environments remain insufficiently integrated at the level of spatial design. This study develops Architectural Nudging for NCD Prevention (ANP), a conceptual framework for translating behavioural nudging principles into architecturally actionable spatial strategies. An integrative literature synthesis was undertaken across public health, built-environment research, choice architecture, Active Design, Biophilic Architecture, Environmental Psychology, and Servicescape Theory. Evidence was organised through a conceptual sequence linking spatial conditions, nudging mechanisms, potential behavioural responses, and architectural design parameters. The resulting ANP framework comprises four interconnected dimensions: Visibility and Wayfinding, Proximity and Movement Path Design, Sensory and Atmospheric Cues, and Social and Normative Spatial Cues. Sixteen architectural strategies are proposed across these dimensions. ANP conceptualises architectural nudging as a relational spatial process rather than an attribute of individual design elements. The framework provides a design-oriented structure for integrating health-supportive behavioural considerations into commercial environments while preserving user autonomy and inclusive access. Empirical testing is required to examine its relationships with observed behaviour and health outcomes.
Keywords: Architectural Nudging, NCD Prevention, Choice Architecture, Commercial Space, Spatial Design

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INTRODUCTION

Non-communicable diseases (NCDs), including cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes, remain a major public health problem worldwide. Physical inactivity and unhealthy diets are two main behavioural risk factors for NCDs that can be changed. However, these behaviours are also influenced by social, commercial, and physical environments (World Health Organization, 2025). Health-related behaviours are influenced not only by individual, socioeconomic, and physical factors but also by the environments where people carry out daily activities and make decisions. Recent studies show that the built environment is related to physical activity. Systematic reviews have found links between physical activity and environmental features such as walkability, connectivity, access to destinations, and other spatial conditions that provide opportunities for movement (Prince et al., 2022). This relationship is important because physical activity includes not only planned exercise but also walking and other types of movement in daily life (World Health Organization, 2024). At the architectural scale, characteristics such as connectivity, accessibility, route configuration, destination proximity, and vertical circulation may consequently structure opportunities for incidental movement and influence whether active routes are visible, convenient, continuous, and integrated with everyday destinations. Dietary behaviour provides another relevant pathway, as food choices occur within environments in which options differ in availability, visibility, placement, proximity, presentation, and accessibility. Recent systematic and scoping reviews of food choice architecture indicate that modifying these environmental characteristics can influence food selection and purchasing, although the magnitude and consistency of effects vary across intervention types and settings (Cesareo et al., 2022; Prowse et al., 2023). Nevertheless, many existing choice-architecture interventions operate at the product, display, retail, or point-of-decision level rather than addressing the broader architectural configuration within which movement and food-related decisions occur.

Commercial environments provide a particularly important setting in which multiple health-related behavioural domains intersect. Shopping centres, retail complexes, markets, food-service environments, and mixed-use commercial developments simultaneously accommodate movement, food-related decisions, sitting, waiting, and social interaction. Their architectural configurations establish relationships among entrances, circulation routes, stairs, lifts, food zones, seating, shared amenities, and gathering spaces, thereby shaping what users encounter, which alternatives become perceptually accessible, and the relative effort required to reach different destinations. Nudge Theory and the broader concept of choice architecture provide a potential behavioural bridge between these spatial characteristics and everyday decision-making. Nudging concerns the deliberate organisation of a choice environment in ways that may influence behaviour while preserving reasonable alternatives (Thaler & Sunstein, 2008). Recent research further demonstrates the relevance of environmental mechanisms such as placement, proximity, accessibility, visibility, and other contextual modifications in supporting healthier food choices (Prowse et al., 2023). Evidence on Active Design suggests that building-design characteristics may support opportunities for physical activity and contribute to reductions in sedentary behaviour, although the strength and consistency of evidence vary across specific outcomes and settings (Chinazzo & Wang, 2026; Engelen, 2020). Architecture also contains complementary approaches relevant to health-supportive environments: Biophilic Architecture and Environmental Psychology address relationships among natural features, environmental qualities, experience, and well-being, with recent systematic reviews reinforcing the potential relevance of daylight, natural views, vegetation, thermal comfort, and related environmental parameters (Al Khatib et al., 2024; Tekin et al., 2023), while Servicescape Theory provides an established basis for understanding how spatial layout and ambient conditions structure user experience within commercial environments (Bitner, 1992).

Despite these complementary bodies of knowledge, behavioural mechanisms and architectural spatial configuration remain insufficiently integrated at the level of design translation. The research problem is therefore not simply a lack of individual health-supportive design strategies, but a behavioural-spatial translation gap between evidence explaining how choice environments may influence behaviour and architectural knowledge concerning how physical environments are spatially configured.

This study addresses this gap by developing Architectural Nudging for NCD Prevention (ANP) as a conceptual and design-oriented framework for health-supportive commercial spaces. The study has three objectives: (1) to identify health-related behavioural domains relevant to architectural intervention in commercial environments; (2) to synthesise relationships among spatial conditions and plausible nudging mechanisms; and (3) to translate these relationships into an architectural framework and actionable design parameters. Accordingly, the central research question is: How can architectural nudging be translated into spatial design strategies that support healthier everyday behaviours in commercial spaces? The study does not attempt to demonstrate that architectural design causes behavioural change or directly prevents NCDs. Instead, it establishes a theoretically informed framework through which spatial conditions can be related to plausible behavioural mechanisms and subsequently examined through empirical research.

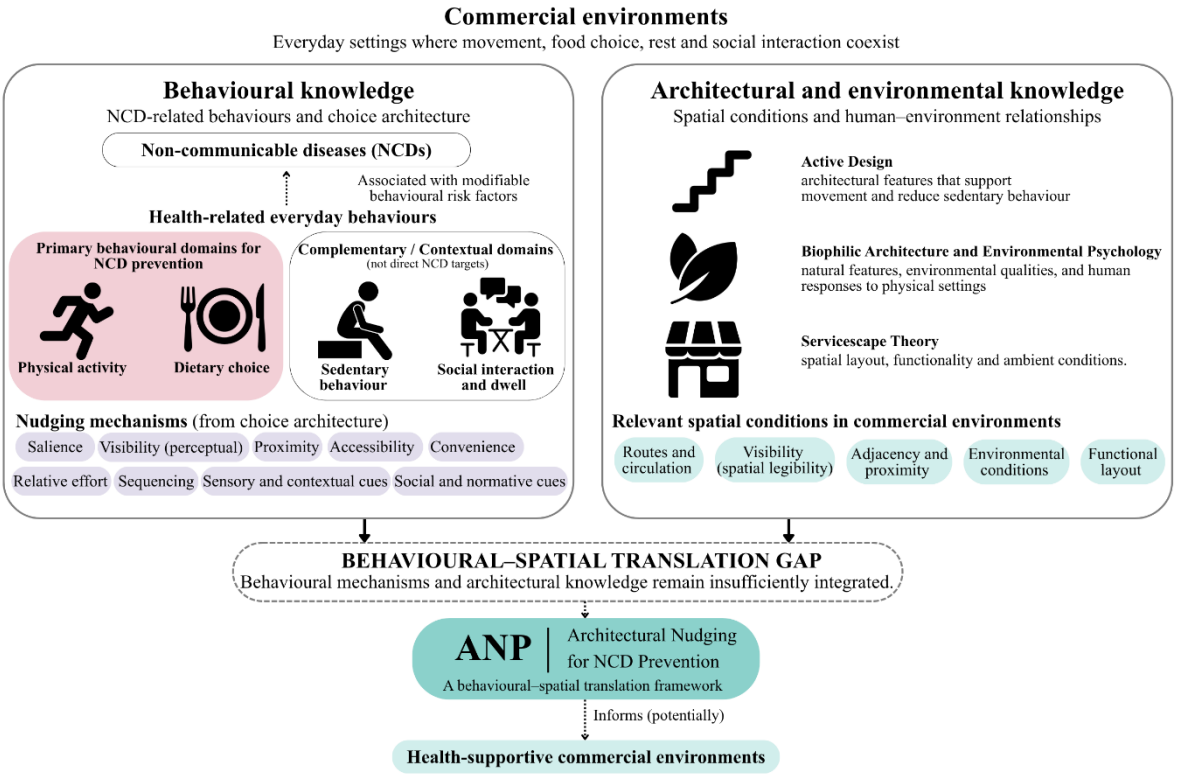


Figure 1 Research Problem and Conceptual Position of ANP

LITERATURE REVIEWS

NCD Prevention and Health-Related Behaviour

Four major modifiable behavioural risk factors are commonly associated with NCDs: tobacco use, harmful alcohol use, physical inactivity, and unhealthy diets. However, these behaviours are not equally amenable to intervention through architectural design. For the present framework, physical activity and healthier dietary choice are identified as the two primary behavioural domains because both occur repeatedly within everyday commercial environments and contain spatial components that may be influenced by architectural configuration. Physical

activity is relevant to architecture because opportunities for movement are partly structured through the organisation of routes and destinations; walking between functions, choosing stairs, and moving through connected spaces can contribute to incidental physical activity. Current Active Design guidance provides an architectural approach for integrating such movement opportunities into everyday routines through building and site design (City of New York, 2025), while recent systematic evidence further demonstrates associations between built-environment characteristics and physical activity and indicates that interventions improving accessibility, destinations, and environments for active movement can support increased physical activity (Pontin et al., 2022; Zhang et al., 2022). Dietary choice constitutes the second primary domain, as food-related decisions occur within spatial contexts in which options are encountered in particular locations and sequences. Recent reviews of choice-architecture interventions indicate that environmental modifications involving availability, placement, proximity, salience, and other contextual cues can influence food selection and purchasing, although their effectiveness varies across intervention types and settings (Cesareo et al., 2022). At an architectural scale, food outlets, displays, queues, circulation routes, and dining areas form a broader spatial context within which these choices occur. Two additional domains are relevant but are treated differently: sedentary behaviour is considered a complementary domain because commercial environments contain seating, waiting, and resting conditions that structure opportunities for sitting and movement, while social interaction and dwell patterns are treated as contextual rather than direct NCD behavioural targets, as commercial spaces allow people to observe others, gather, interact, and remain within shared environments, potentially creating social conditions within which other behaviours become more or less visible. This distinction is important because ANP does not treat every desirable aspect of well-being as an equivalent NCD-prevention pathway; instead, it prioritises physical activity and dietary choice while recognising that sedentary, social, and experiential conditions form part of the wider behavioural context.

Health-Supportive Spatial Conditions in Commercial Environments

Built-environment research indicates that behaviour occurs within spatial systems that structure opportunities and constraints. Recent systematic reviews identify characteristics such as connectivity, destination proximity, accessibility, walkability, and access to facilities as relevant to physical activity, although the strength and consistency of these relationships vary across spatial contexts and behavioural outcomes (Nigg et al., 2024; Zhang et al., 2024). For architectural analysis, these characteristics can be extended to include visibility, spatial legibility, environmental quality, and the distribution of activities. Connectivity and route configuration concern how spaces and destinations are linked; within commercial buildings, entrances, corridors, stairs, escalators, lifts, retail units, food areas, and amenities form circulation networks whose configuration establishes route continuity, alternatives, and spatial relationships between activities. Proximity and adjacency influence the relative effort associated with reaching different destinations, as the location of stairs relative to escalators, food zones relative to primary circulation, or amenities relative to gathering spaces may affect the convenience with which different opportunities are encountered. Importantly, proximity depends on the location of other available options. An option is not simply “near” or “far” without considering the alternatives. Visibility and spatial legibility refer to how easily people can see and understand routes, destinations, and facilities. Clear views, open spaces, landmarks, the arrangement of movement routes, and wayfinding signs can help people see and find different options. For example, a staircase that is available but hidden from view creates a different choice environment from a staircase that is clearly visible from a main circulation area. Commercial food environments introduce another spatial layer, as food options are distributed across outlets, displays, dining zones, queues, and circulation sequences. Food-environment research indicates that availability, placement, and proximity are relevant

components of choice architecture and can structure how food alternatives are encountered (Kraak et al., 2017; Slapø et al., 2021). Although architecture does not determine what food operators provide, it can establish where food choices are encountered and their visual and spatial relationships to pedestrian movement. Environmental quality also shapes the context in which movement and staying occur, with daylight, shading, lighting, vegetation, natural materials, acoustic and thermal conditions, and indoor-outdoor transitions contributing to the experience of circulation and shared spaces. Evidence from recent biophilic-design research supports the relevance of several such environmental characteristics to health and well-being, although much of this evidence derives from specific settings and should not be interpreted as demonstrating direct behavioural effects within commercial environments (Al Khatib et al., 2024; Tekin et al., 2023). Commercial environments should therefore be understood as integrated spatial systems, in which a staircase, food outlet, seating area, or courtyard cannot be interpreted independently of surrounding routes, destinations, environmental conditions, and available alternatives.

Nudge Theory and Choice Architecture

Nudge Theory provides a behavioural basis for understanding how the organisation of an environment may influence decision-making without removing available alternatives. Thaler and Sunstein (2008) conceptualise nudging within the broader notion of choice architecture, which concerns how options are organised and presented within a decision environment. More recent reviews similarly describe nudges as interventions within decision contexts that steer behaviour while preserving freedom of choice, while also highlighting continuing debate concerning their definition, justification, and effectiveness (Congiu & Moscati, 2022; Mertens et al., 2022). The distinction between choice architecture and a nudge is particularly important for architectural application because, although all environments inevitably contain some arrangement of choices, not every environmental characteristic constitutes a deliberate nudge. Within the ANP framework, potentially relevant choice-architecture mechanisms are interpreted in spatial terms, including salience and visibility, proximity and accessibility, convenience and relative effort, sequencing and placement, and social or contextual cues. Evidence across behavioural domains indicates that choice-architecture interventions can influence behaviour, although their effectiveness varies according to the intervention technique and behavioural domain (Mertens et al., 2022). These mechanisms help explain how spatial conditions may influence behaviour, but they are not the same as architectural elements. For example, a staircase is not automatically a nudge. Its influence on behaviour may depend on how easy it is to see and reach, whether it connects to main walking routes, and whether people see it as a practical alternative to lifts or escalators. Similarly, a food outlet is not automatically a nudge for healthier eating. Its location, visibility, order along a route, and position compared with other food options may affect what people notice and how easy it is to reach. However, these effects also depend on the available choices, individual needs, and the surrounding context. ANP therefore conceptualises architectural nudging as a relationship in which spatial conditions operate through plausible nudging mechanisms to create potential behavioural responses. This relationship is explicitly non-deterministic and provides an interpretive structure through which architectural conditions can be connected with behavioural theory without claiming that a particular spatial configuration necessarily produces a particular response.

Architectural and Environmental Approaches

Three established areas provide complementary architectural knowledge for ANP: Active Design, Biophilic Architecture and Environmental Psychology, and Servicescape Theory. Active Design provides an important architectural basis for integrating physical activity into everyday environments through building and site design. Its current guidance includes the design and location of stairs, pedestrian routes, connected circulation, access to destinations,

and other opportunities for daily movement (City of New York, 2025). Research on Active Design also suggests that building design may support stair use and reduce sedentary behaviour, although evidence for increasing overall physical activity remains mixed and varies across interventions and settings (Engelen, 2020; Mustafa & Ali, 2023). Biophilic Architecture and Environmental Psychology extend the discussion beyond movement and circulation by considering how natural features and environmental qualities may influence people's experience and well-being. These approaches consider features such as daylight, vegetation, views of nature, natural materials, and thermal comfort. Foundational research in environmental psychology demonstrated the potential relationship between exposure to natural environments and restorative outcomes (Ulrich, 1984), while more recent research on biophilic design identifies daylight, views, fresh air, thermal comfort, and other natural or environmental features as potentially relevant to health and well-being (Zhong et al., 2022). However, much of this evidence comes from specific settings, particularly workplaces and healthcare environments, and should therefore not be interpreted as evidence of direct effects on physical activity, dietary choice, or NCD prevention in commercial environments. Servicescape Theory is particularly relevant to commercial environments. Bitner (1992) describes service environments through three main components: ambient conditions, spatial layout and functionality, and signs, symbols, and artefacts, providing a useful basis for understanding how user experience and behaviour take place within an integrated physical environment. Servicescape Theory, however, centres on consumer and service experiences rather than health outcomes. Together, these approaches provide complementary foundations for ANP: Active Design contributes knowledge about movement and circulation; Biophilic Architecture and Environmental Psychology contribute knowledge about sensory and environmental experience; Servicescape Theory contributes an understanding of commercial spatial settings; and Nudge Theory provides a behavioural basis for interpreting how the organisation of alternatives may influence everyday choices.

Research Gap and Conceptual Basis

The literature reveals four related gaps. First, evidence concerning physical activity, dietary choice, sedentary behaviour, and social behaviour is distributed across different research domains, even though these behaviours frequently coexist within commercial environments. Second, behavioural mechanisms and architectural approaches remain insufficiently connected: behavioural research explains how salience, convenience, accessibility, sequencing, and contextual cues may affect choice, whereas architectural research describes physical configurations without always making the underlying behavioural mechanisms explicit. Third, a behavioural-spatial translation gap remains, as evidence that proximity influences choice does not itself explain how proximity should be interpreted architecturally in relation to entrances, circulation, stairs, food destinations, or shared spaces. Fourth, commercial environments combine multiple behavioural and spatial processes but remain insufficiently integrated into health-oriented architectural frameworks. The resulting research need is therefore not another isolated design feature or behavioural theory, but an architectural translation structure capable of connecting existing behavioural evidence with spatial decision-making while retaining appropriate limits on causal claims.

RESEARCH METHODOLOGY

Research Design

This study adopted a qualitative, integrative framework-development design (Snyder, 2019; Torraco, 2016) to synthesise interdisciplinary knowledge into an architecturally actionable conceptual framework, rather than to measure behavioural effects or evaluate specific commercial buildings. The integrative literature synthesis followed four stages: evidence identification, conceptual classification, behavioural-spatial mapping, and architectural

translation. First, foundational theories, research reviews, empirical studies, and architectural guidelines from public health, behavioural science, architecture, environmental psychology, and commercial-environment research were examined for their conceptual relevance to NCD-related behaviours, spatial design, and behavioural mechanisms. No systematic review protocol was applied. Physical activity and healthier dietary choice were prioritised, while sedentary behaviour and social interaction/dwell were considered complementary or contextual domains. Second, recurring spatial characteristics, including visibility, accessibility, connectivity, proximity, circulation hierarchy, spatial sequence, environmental quality, food-related organisation, seating, and shared-space configuration, were classified by architectural function and behavioural relevance. Third, these characteristics were mapped against plausible mechanisms derived from Nudge Theory and choice architecture, including salience, accessibility, convenience, relative effort, sequencing, sensory and contextual cues, and social and normative cues. Finally, the identified relationships were translated into architectural design parameters and grouped by conceptual similarity, spatial function, and nudging mechanism, producing four interconnected ANP dimensions: Visibility and Wayfinding, Proximity and Movement Path Design, Sensory and Atmospheric Cues, and Social and Normative Spatial Cues. These dimensions constitute conceptual categories rather than mutually exclusive or empirically validated classifications.

Analytical Procedure

The analysis followed four connected components: spatial condition, nudging mechanism, potential behavioural response, and architectural design parameter, as shown in Figure 2. Spatial conditions include features of commercial environments that can be observed or described, such as stair visibility, route connectivity, distance to destinations, and seating arrangements. These conditions were examined using nudging mechanisms based on existing theories, including salience, accessibility, convenience, relative effort, sequencing, sensory cues, and social visibility. This helped identify possible behavioural responses, mainly physical activity and healthier food choices, without assuming that actual behaviour would change. Relationships were included when they were supported by concepts from the reviewed literature and could be applied to spatial design decisions in commercial environments. These relationships were then used to develop architectural strategies by identifying practical design parameters linked to specific spatial conditions and possible nudging mechanisms. Design parameters with similar concepts were grouped into separate strategies based on their architectural functions and practical use in design. The final framework includes sixteen strategies, with four strategies in each ANP dimension (V1-V4, P1-P4, A1-A4, and S1-S4), as shown in Table 2. This structure was developed to organise design parameters based on concepts rather than statistical analysis. It does not aim to include every possible design intervention. Each strategy was also considered based on three principles: keeping reasonable choices available, ensuring accessibility for different users, and meeting commercial and operational requirements.

The proposed strategies were reviewed to see how they could work together and were grouped into four example strategy bundles based on their shared spatial goals and how they could be combined in commercial environments. These comprised active circulation (V1, P1, A4), food-route integration (V3, P3), comfortable movement (P2, A1, A2, P4), and social-space integration (S1-S4, P4), as illustrated in Figures 4a-4d. The bundles show possible ways to combine architectural conditions, but they do not cover all possible combinations of the sixteen strategies. Strategies not included in these examples may be used in other combinations depending on the spatial context and design goals. No numerical measures of effectiveness or evidence ratings were given to individual strategies or their combinations. Further studies using real-world data are needed to test how effective these strategies are in changing behaviour.

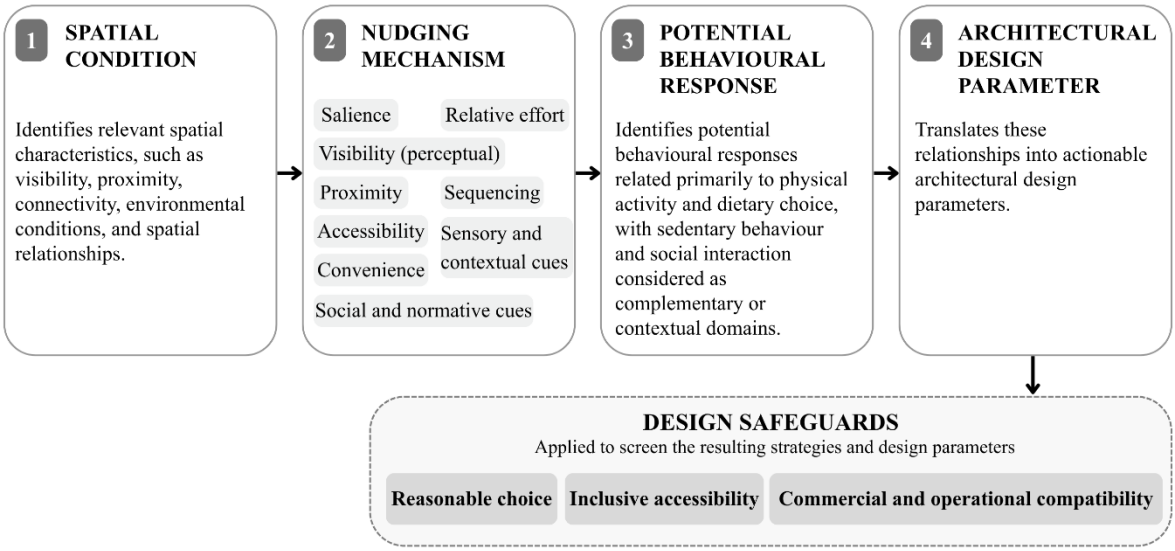


Figure 2 ANP Analytical Translation Process

RESEARCH FINDINGS

The Architectural Nudging for NCD Prevention Framework

The synthesis led to the ANP framework, which includes four connected design dimensions: Visibility and Wayfinding; Proximity and Movement Path Design; Sensory and Atmospheric Cues; and Social and Normative Spatial Cues. Visibility and Wayfinding focuses on how easily people can see and understand routes, destinations, and available options. It uses mechanisms such as salience and visibility, with design features including clear views, visible landmarks, easy-to-understand routes, and the visibility of stairs, food destinations, and other available options. This dimension may support physical activity and healthier food choices by helping people notice the options available to them. Proximity and Movement Path Design focuses on distance, the location of spaces in relation to each other, connectivity, accessibility, relative effort, route choices, and the order of spaces along a route. It uses mechanisms such as proximity, accessibility, convenience, relative effort, and path structure. This dimension may be related to physical activity, food choices, and sedentary behaviour. Sensory and Atmospheric Cues focuses on environmental features related to movement and shared spaces, such as daylight, shade, plants, natural materials, lighting, sound conditions, environmental comfort, and connections between indoor and outdoor spaces. These features mainly provide sensory and environmental support. Therefore, ANP considers them as conditions that may support behaviour rather than directly cause behavioural change. Social and Normative Spatial Cues addresses the spatial relationships among people, activities, circulation, seating, and gathering spaces through parameters such as seating and gathering configurations, visual connections with circulation, and the visibility of shared activities. These conditions may contribute social and normative information and shape the broader context in which movement, staying, and other observable behaviours occur.

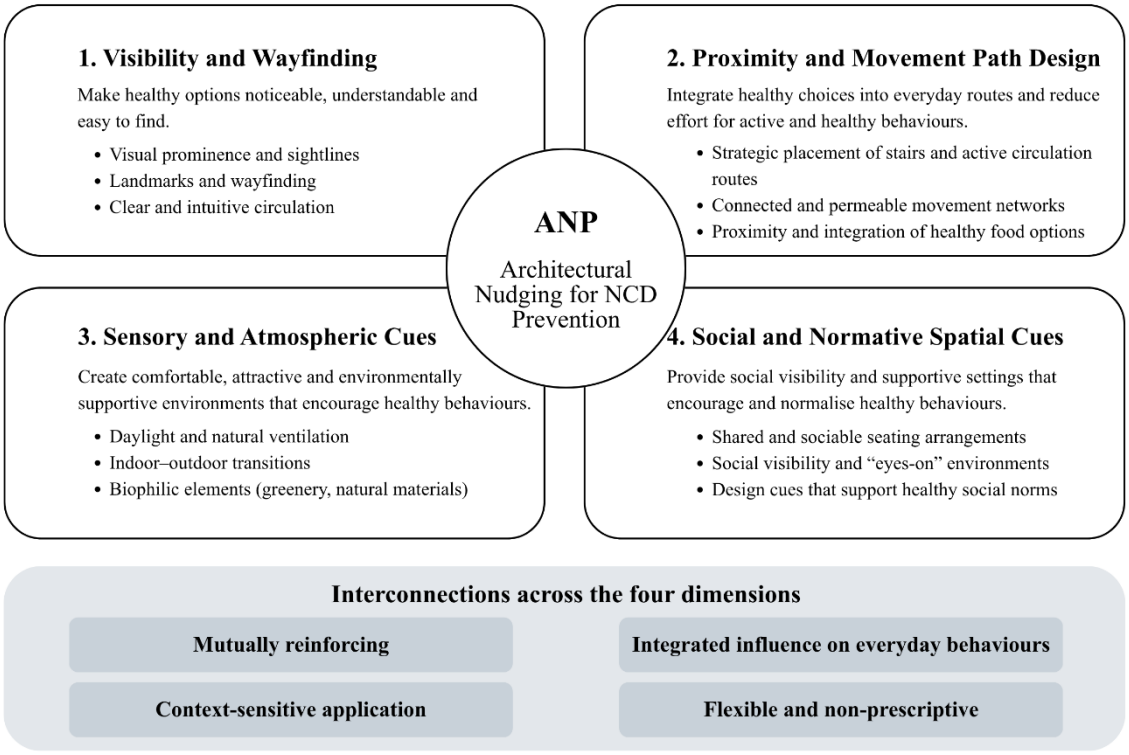


Figure 3 The ANP Framework: Four Interconnected Dimensions

Table 1 Consolidated ANP framework

ANP dimension	Key spatial parameters	Principal mechanism	Potential behavioural relevance
Visibility and Wayfinding	Sightlines, visual prominence, landmarks, circulation legibility, visibility of stairs and destinations	Salience and visibility	Physical activity; healthier dietary choice
Proximity and Movement Path Design	Connectivity, adjacency, route alternatives, relative distance, circulation hierarchy, spatial sequence	Proximity, accessibility, convenience, relative effort, path structure	Physical activity; healthier dietary choice; sedentary behaviour
Sensory and Atmospheric Cues	Daylight, shading, vegetation, natural materials, environmental quality, indoor-outdoor transitions	Sensory and contextual cues	Movement and dwell patterns; environmental engagement
Social and Normative Spatial Cues	Seating and gathering configuration, visual relationships with circulation, visibility of shared activities	Social visibility and normative cues	Social interaction and dwell; contextual reinforcement of other behaviours

The four dimensions are not mutually exclusive. A single architectural element may participate in several dimensions depending on its spatial relationships. This finding is fundamental to ANP: architectural nudging is relational rather than element based.

Architectural Translation of the ANP Dimensions

The conceptual synthesis produced sixteen architectural strategies, expressed as adaptable design parameters rather than prescriptive solutions (Table 2). The strategies translate the four ANP dimensions into spatial parameters that can inform architectural decision-making in commercial environments. Visibility and Wayfinding strategies address visual connection, spatial legibility, and the visibility of routes and destinations. Proximity and Movement Path Design strategies focus on the positioning, connectivity, and sequencing of circulation, destinations, and amenities. Sensory and Atmospheric Cues address environmental conditions associated with movement and shared spaces, while Social and Normative Spatial Cues focus on the spatial and visual relationships among circulation, shared spaces, and activities.

Table 2 Sixteen Architectural Strategies of the ANP Framework

ANP Dimension	Code	Architectural Strategy
Visibility and Wayfinding	**V1**	Establish visual connections between entrances, primary circulation nodes, stairs, and other active routes.
	V2	Create a legible circulation hierarchy through clear spatial organisation, landmarks, and consistent wayfinding.
	V3	Position food-related destinations and displays so that a range of options, **including healthier alternatives where provided**, can be visually encountered from primary routes.
	V4	Maintain equivalent visibility and legibility of lifts, ramps, and step-free routes to preserve inclusive access.
Proximity and Movement Path Design	**P1**	Position stairs on or adjacent to primary movement routes so that their spatial convenience is comparable with mechanically assisted circulation.
	P2	Provide connected and continuous pedestrian networks with meaningful route alternatives between destinations.
	P3	Integrate food-related destinations with primary circulation and spatial sequences so that available choices can be encountered without unnecessary detours.
	P4	Distribute seating, waiting areas, and amenities in relation to circulation and activity zones while maintaining adequate opportunities for rest.
Sensory and Atmospheric Cues	**A1**	Support continuous pedestrian movement through appropriate daylight, shading, ventilation, weather protection, and related environmental conditions.
	A2	Integrate vegetation, natural materials, daylight, views, and other biophilic characteristics with circulation and shared spaces.
	A3	Provide lighting, acoustic, and sensory conditions that support environmental comfort.
	A4	Enhance the environmental quality of stairs and active circulation routes through daylight, views, materials, and spatial openness.
Social and Normative Spatial Cues	**S1**	Establish visual relationships between primary circulation and shared activity areas.
	S2	Configure seating, edges, and gathering areas in relation to circulation to provide opportunities for both interaction and rest.

S3	Create spatial and visual connections among circulation, dining, and shared spaces.
S4	Integrate flexible shared spaces with circulation networks to accommodate a range of communal and movement-related activities.

Note. These strategies are expressed as adaptable architectural design parameters rather than fixed or prescriptive solutions. Their relevance depends on relationships among multiple spatial conditions and contextual factors, including accessibility, climate, commercial operation, and building configuration.

Rather than predicting behaviour, the strategies identify spatial parameters through which health-related behavioural opportunities may become more visible, accessible, convenient, comfortable, or socially perceptible.

Interrelationships and Strategy Bundles

The proposed architectural strategies operate through interrelated spatial conditions rather than as isolated interventions. Four illustrative strategy bundles were developed to demonstrate how complementary design parameters may be integrated within commercial environments (Figures 4a-4d). Their potential applications are illustrated through a hypothetical multi-storey shopping centre, presented as a design scenario rather than an empirically examined case.

The active-circulation bundle (V1, P1, A4) combines stair visibility, spatial convenience, and environmental quality. A staircase located on the main circulation route but hidden behind a service core may be easy to reach but difficult to see (P1 without V1). In contrast, a clearly visible staircase located away from the main walking route may be easy to notice but less convenient to use (V1 without P1). Placing the staircase along the main route with clear views from the entrance atrium (V1, P1), together with daylight, views, and open spaces (A4), can address these conditions at the same time. This combination can help guide decisions about stair location, visual connections, and circulation design. To ensure accessibility, lifts, ramps, and step-free routes should also remain easy to see and understand (V4), although V4 is not part of this example bundle (Figure 4a).

The food-route bundle (V3, P3) combines food visibility with the location of food destinations along walking routes. For example, a food outlet may be clearly visible from the main corridor but offer few healthier food options. At the same time, another outlet offering healthier choices may be located along a secondary route that is harder to reach. Placing food destinations along main walking routes (P3) and making sure that people can see the available food options, including healthier choices (V3), can help address these spatial problems together. This approach can help guide decisions about the location of food zones, walking routes, and the direction of food displays. However, its potential health benefits still depend on the food options actually available and how commercial spaces are operated (Figure 4b).

The comfortable-movement bundle (P2, A1, A2, P4) combines connected walking routes with environmental comfort and places to rest. In the example shopping centre, continuous walkways connecting retail areas and shared facilities (P2) could include daylight, shade, and ventilation (A1), plants and natural materials (A2), and seating placed in suitable locations along the routes (P4). Together, these strategies help maintain connected walking routes while providing comfort and meeting different mobility needs. This combination can help guide the planning of walking routes, environmental design, and the location of facilities without limiting opportunities for rest (Figure 4c).

The social-space bundle (S1-S4, P4) combines walking routes, visual connections, shared activities, and seating arrangements. For example, a central atrium could provide flexible spaces for community activities (S4), with clear visual connections to main walking routes (S1), seating and gathering areas along its edges (S2, P4), and connections to nearby dining

and shared spaces (S3). These connections can help guide the layout of shared spaces and activity areas while providing opportunities for both social interaction and rest (Figure 4d).
These examples show that ANP should not be used as a checklist of separate architectural features. Instead, the possible effects of each strategy on behaviour depend on how it connects with other spatial conditions and the wider commercial environment. The bundles show possible design combinations rather than covering all sixteen strategies. They are not based on field observations and do not provide evidence that the strategies can change behaviour. Further studies using real-world data are needed to test their effectiveness.

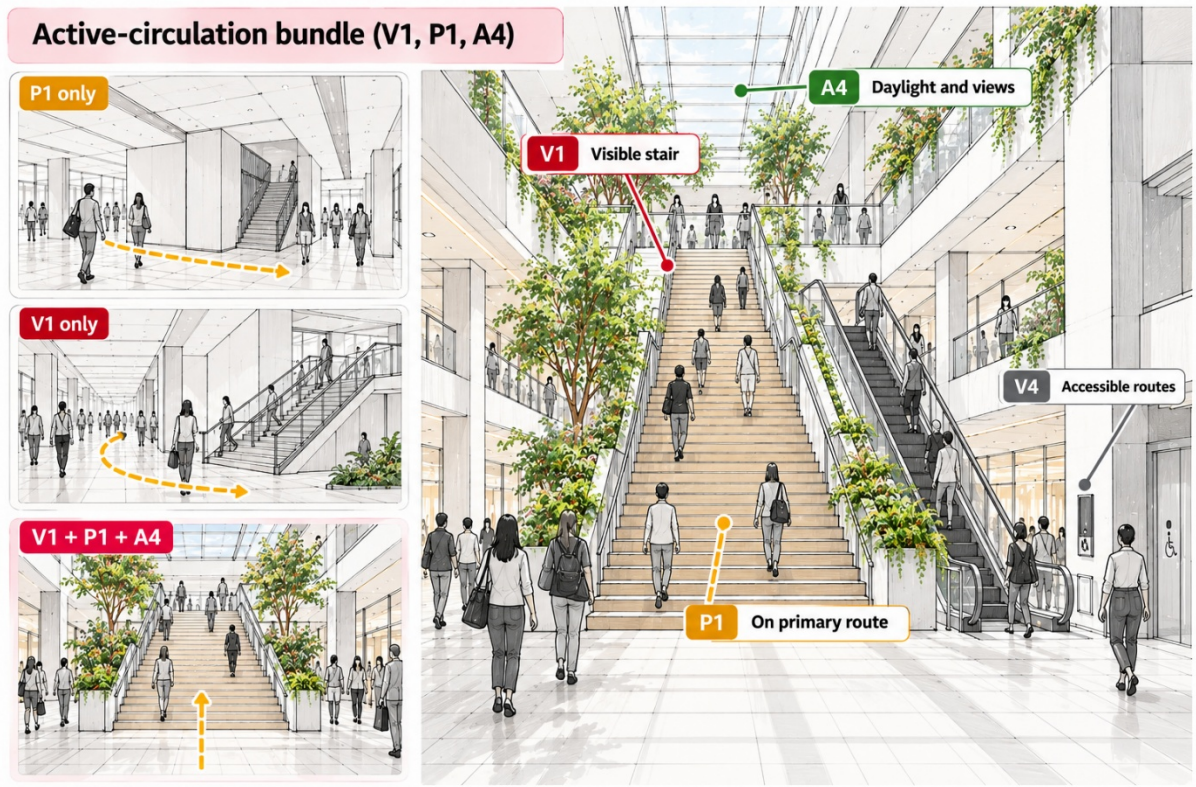


Figure 4a Example of how the active-circulation bundle (V1, P1, A4) could be used in a hypothetical shopping centre. The insets compare a staircase that is easy to reach but hidden from view (P1 only), a staircase that is clearly visible but less convenient to reach (V1 only), and a design that combines visibility (V1), convenient location (P1), and environmental quality (A4). The main illustration shows how these strategies can guide stair location, clear views, and circulation design while keeping accessible alternatives available (V4). Dashed arrows show the main walking routes. V4 is included to support accessibility but is not part of the bundle. These illustrations are hypothetical design examples, not field observations or evidence that the strategies can change behaviour.

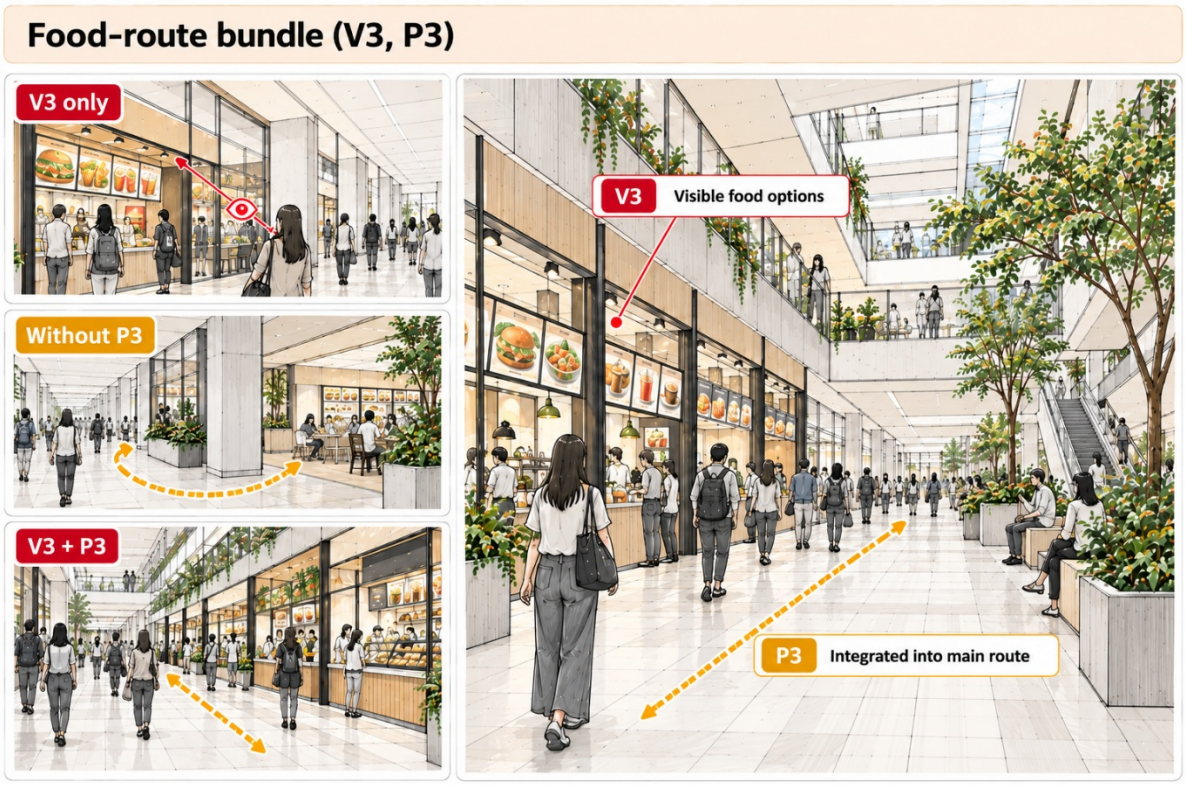


Figure 4b Example of how the food-route bundle (V3, P3) could be used in a hypothetical shopping centre. The insets compare a clearly visible food outlet (V3 only), a food destination located away from the main walking route that requires a detour (without P3), and a design that combines visibility (V3) with a location along the main walking route (P3). The main illustration shows how these strategies can guide the location of food zones, walking routes, and the direction of food displays. However, the potential health benefits depend on the food options actually offered by tenants. Dashed arrows show the main walking routes. These illustrations are hypothetical design examples, not field observations or evidence that the strategies can change behaviour.

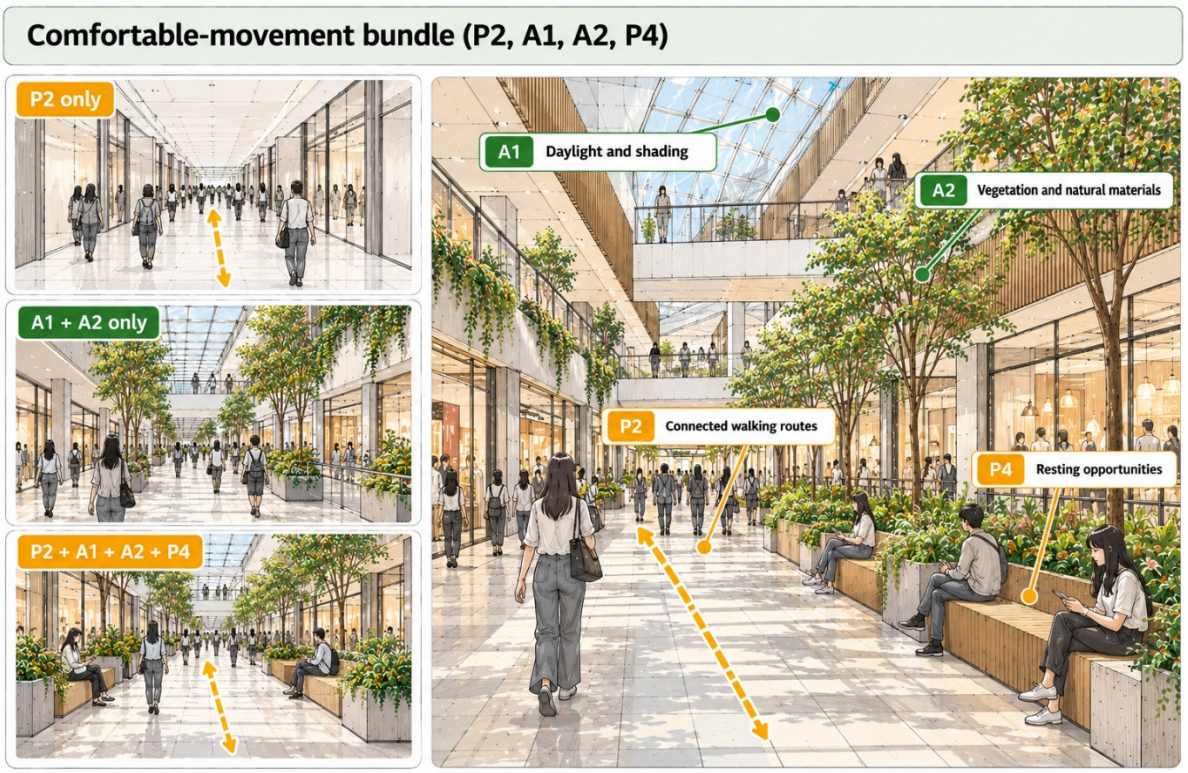


Figure 4c Illustrative application of the comfortable-movement bundle (P2, A1, A2, P4) in a hypothetical shopping centre. The insets contrast connected routes without resting opportunities (P2 only), environmentally enhanced routes without coordinated seating (A1 and A2 only), and an integrated configuration combining route connectivity (P2), daylight and shading (A1), vegetation and natural materials (A2), and distributed seating (P4). The main illustration shows how these strategies jointly inform circulation continuity, environmental comfort, and resting opportunities. Dashed arrows indicate two-way pedestrian circulation. These illustrations are hypothetical design applications, not field observations or evidence of behavioural effectiveness.

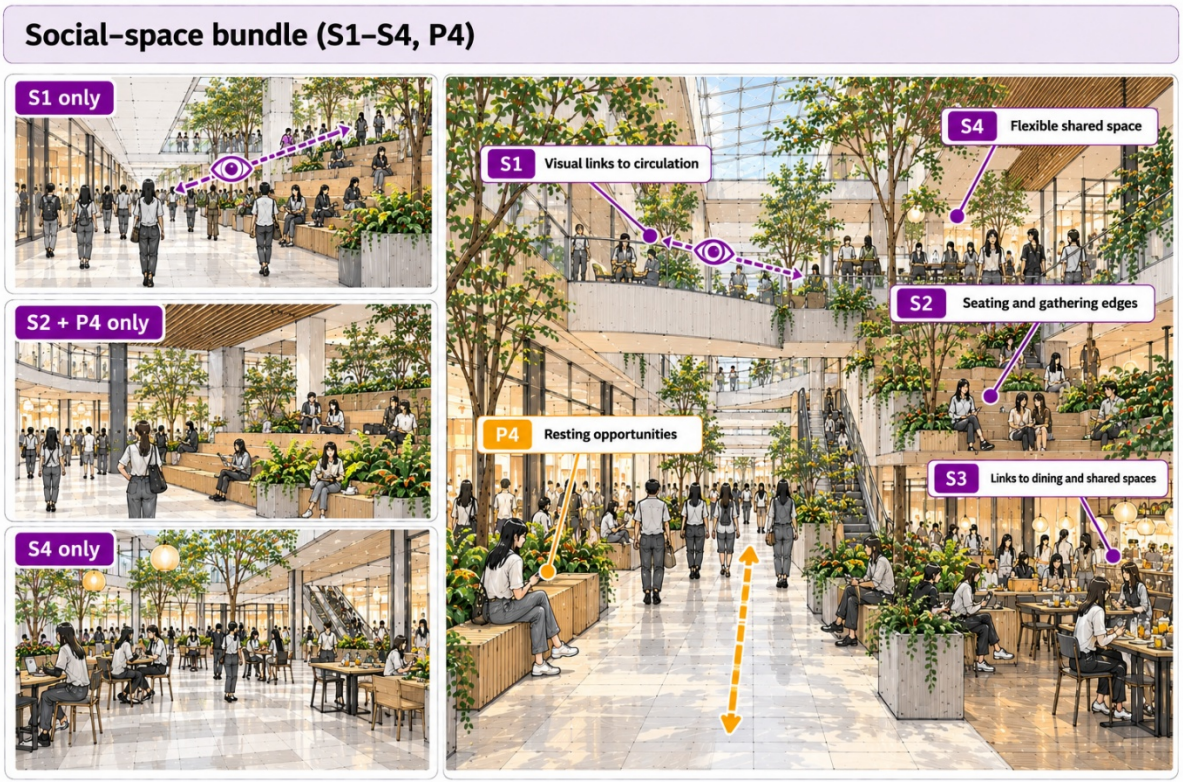


Figure 4d. Illustrative application of the social-space bundle (S1-S4, P4) in a hypothetical shopping centre. The insets show visual links to shared activities (S1 only), seating and gathering edges (S2 and P4 only), and flexible shared space (S4 only). The main illustration integrates visual connections (S1), gathering edges (S2), links to dining and shared spaces (S3), flexible shared space (S4), and resting opportunities (P4), informing shared-space organisation. Orange dashed arrows indicate primary pedestrian circulation; purple dashed lines and eye symbols indicate visual connections. These illustrations are hypothetical design applications, not field observations or evidence of behavioural effectiveness.
Note (Figures 4a-4d). Strategy codes are colour-coded by ANP dimension: V (red), P (gold), A (green), and S (purple); grey indicates an accessibility safeguard.

Design Safeguards and Application

The synthesis also identified safeguards necessary for responsible architectural nudging. Supporting active circulation should not reduce the visibility, convenience, or accessibility of lifts, ramps, and step-free routes, as a strategy that increases physical activity opportunities for some users while creating barriers for others would conflict with the framework's principle of inclusive choice. Similarly, movement-oriented environments should not be designed through the removal of necessary seating, since resting opportunities remain essential for older people, people with disabilities, children, caregivers, and other users; the relevant architectural question is therefore how movement and rest can coexist within the spatial system. Food-related architectural strategies also require coordination with commercial operations because, although architecture may affect exposure and accessibility, it cannot independently determine tenant mix, product availability, price, or nutritional quality, and increased food visibility is therefore not inherently health-supportive. Sensory strategies must likewise remain context-sensitive, as the feasibility and performance of daylight, vegetation, natural materials, shading, and semi-outdoor spaces depend on climate, building configuration, maintenance, energy requirements, and operational conditions. Within these safeguards, ANP can be applied across several design stages: site planning can address entrances, connectivity, destination

distribution, and internal-external relationships; schematic design can address vertical circulation, sightlines, route hierarchy, food zones, courtyards, and shared spaces; detailed and interior design can address lighting, materials, planting, seating, acoustics, and wayfinding; and operational coordination can address display orientation, tenant interfaces, temporary layouts, and shared-space programming. The framework is therefore potentially both diagnostic, for examining existing environments, and generative, for informing new design decisions, although its evaluative use requires empirical evidence linking spatial parameters with observed behavioural responses.

DISCUSSION AND CONCLUSION

Interpreting Architectural Nudging

This study examined how behavioural nudging can be translated into spatial design strategies for health-supportive commercial environments. The resulting ANP framework addresses this question by establishing an explicit conceptual link among spatial conditions, nudging mechanisms, potential behavioural responses, and architectural design parameters. This translation represents a central conceptual contribution of the study by connecting behavioural concepts related to salience, accessibility, convenience, relative effort, and the arrangement of options with built-environment research on connectivity, movement routes, and destination accessibility. Importantly, ANP does not treat architectural elements as nudges in themselves. Instead, it distinguishes between the broader spatial environment and the specific ways in which spatial conditions may influence behavioural choices. A staircase is not inherently health-promoting, a food zone is not inherently a dietary nudge, and vegetation does not independently constitute an NCD-prevention intervention; their potential behavioural relevance instead emerges from spatial relationships and the mechanisms through which these relationships may structure behavioural opportunities. Accordingly, the four ANP dimensions perform differentiated roles: Visibility and Wayfinding and Proximity and Movement Path Design have the most direct conceptual relationships with physical activity and dietary choice through mechanisms such as salience, accessibility, convenience, and relative effort; Sensory and Atmospheric Cues primarily provide enabling environmental conditions; and Social and Normative Spatial Cues contribute to the broader social context within which behaviours may become visible and shared. This differentiation prevents the framework from treating every desirable architectural quality as an equivalent pathway to NCD prevention and maintains ANP as a non-deterministic framework for interpreting the potential behavioural relevance of spatial design.

Relationship to Existing Approaches

ANP does not replace Nudge Theory, Active Design, Biophilic Architecture, Environmental Psychology, or Servicescape Theory. Instead, it combines these approaches and explains their concepts in architectural terms. Nudge Theory helps explain how the way choices are arranged in an environment may influence everyday decisions. ANP applies this idea to architectural design by looking at how routes, clear views, the location of spaces in relation to each other, and the order of spaces along a route form lasting features of the choice environment. Active Design provides a useful basis for strategies related to movement, especially through architectural features that encourage stair use and help reduce sedentary behaviour (Mustafa & Ali, 2023). ANP builds on this foundation and also includes dietary choice, sensory qualities, and social context. Biophilic Architecture and Environmental Psychology help explain how natural features and environmental qualities are related to people's responses to physical spaces. In ANP, these features are mainly seen as conditions that may support behaviour, unless stronger evidence shows a more direct effect on behaviour. Servicescape Theory helps explain how spatial layout, the functions of spaces, surrounding environmental conditions, and environmental cues influence people's experiences in commercial and service environments

(Bitner, 1992). ANP uses this perspective to consider opportunities for health-related behaviours without assuming that commercial goals and health goals always support each other. The main contribution of ANP is not to create sixteen completely new architectural techniques, as many of these techniques already exist. Instead, it brings them together in a clear framework that connects spatial conditions, behavioural mechanisms, their relevance to behaviour, and architectural design actions.

Implications for Architectural Practice

The framework suggests that health-supportive design should be considered during architectural decision-making rather than solely through interventions introduced after buildings are occupied, particularly because decisions concerning entrances, circulation hierarchy, vertical circulation, adjacency, food zones, shared spaces, and indoor-outdoor relationships are embedded within the spatial organisation of buildings. Within this approach, ANP provides architects with a structure for asking behavioural questions about spatial decisions. Rather than considering only whether a staircase exists, designers can examine whether it is visible, convenient, integrated with primary circulation, environmentally supportive, and balanced with inclusive alternatives. Similarly, rather than considering only whether food facilities are provided, they can examine how different food destinations relate to circulation, visibility, spatial sequence, and shared spaces. The framework may therefore support design evaluation and voluntary health-oriented guidance; however, its translation into formal building standards or certification criteria would require stronger empirical evidence concerning the behavioural implications of individual spatial parameters and strategy bundles.

Limitations and Future Research

Several limitations define the scope of this study. First, the ANP framework was developed through an integrative literature synthesis rather than a systematic review or meta-analysis. Its purpose was interdisciplinary conceptual integration, and the strength of the underlying evidence therefore varies across the proposed relationships. Second, the evidence was drawn from different spatial scales and research settings, including neighbourhood walkability, workplace stair use, food-retail choice architecture, public-space behaviour, and environmental psychology. Findings from these contexts cannot automatically be assumed to apply in the same way to commercial architecture. ANP therefore translates existing knowledge into conceptually informed relationships and architectural design parameters rather than treating cross-context findings as established behavioural effects. Third, no field observations, individual behavioural data, or health outcomes were collected during this phase of the research. Consequently, the framework does not demonstrate that the proposed spatial configurations increase walking or stair use, promote healthier dietary choices, reduce sedentary behaviour, or prevent NCDs. Future research should proceed in two stages. The first involves empirical spatial application through comparative analysis of actual commercial environments, using architectural plans, circulation mapping, sightline analysis, photographic documentation, structured field observation, and spatial recording to operationalise and examine the four ANP dimensions. This stage would assess the applicability of the framework to existing spatial configurations, identify recurring spatial patterns and contextual differences, and inform the refinement of its architectural design parameters without claiming behavioural validation. The second stage involves behavioural investigation, integrating spatial analysis with methods such as behavioural mapping, pedestrian tracking, stair-use observation, user-perception studies, eye-tracking, post-occupancy evaluation, environmental measurement, or quasi-experimental approaches. Such research could progressively examine whether individual spatial parameters or combinations of strategies are associated with measurable behavioural differences. Within these boundaries, ANP should be understood as a conceptual and design-oriented translation framework rather than a predictive behavioural or health model. Its

contribution lies in establishing a structured architectural basis for future empirical investigation of the potential behavioural relevance of commercial-space design.

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