# Architectural characteristics that contribute to well-being and experienced safety for innovative healthcare centres.

**Improving the experience of a healthcare centre through architecture.**

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**Abstract**

Urban healthcare centres face considerable pressure due to the negative health impacts associated with cities and increasing urban density. These challenges add strain to healthcare providers already dealing with imbalances in care provision. Research indicates that environmental factors play an important role in physical recovery and stress reduction, yet many outpatient care facilities lack these beneficial features, presenting an opportunity for enhancement. By integrating healing architectural characteristics, patients can be encouraged to communicate openly about their health concerns, experiencing reduced mental and physical stress during examinations or treatments. Implementing such features not only reduces reliance on pain medication but also reduces aggression toward healthcare providers and diminishes the need for recurrent visits. This paper hypothesizes that patients' stress levels have escalated since the COVID-19 pandemic, primarily due to concerns about airborne diseases in healthcare settings. Architectural features can mitigate the risk of contracting such diseases, potentially enhancing the perceived safety within these environments. Through a review of existing literature, this paper identifies current and future hurdles in healthcare centres, including airborne diseases, and proposes evidence-based design solutions aimed at enhancing patients' visiting experiences.

**Key concepts/words**
Aesthetic experience, environmental psychology, virtual reality, architecture, design characteristics

# Introduction

In Dutch architectural practice, designs for healthcare facilities were traditionally limited to a select group of architects. However, a notable shift has occurred as healthcare development projects are increasingly being included in public design competitions (Willekens, Krabshuis, & Miedema, 2022)These competitions foster more professional competition, igniting architectural creativity and innovation.

The objective of outpatient care facilities in a neighborhood is to uphold public physical and mental health and reduce admissions to inpatient care facilities. These centers accommodate a range of professionals, including general practitioners, psychologists, physicians, diarists, dentists, and social workers. The variation depends on the facility's size and the number of people it serves.

This research aims to address a specific case presented in a competition for a new healthcare center on Oeverparklaan, lot M3a, located in Amsterdam, the Netherlands. The building's goal is to provide healthcare services to approximately 4,000 to 6,000 inhabitants of the newly constructed 'Strandeiland' in the IJmeer. The competition's program will serve as the foundation for exploring architectural functions and complexities. The size of the building can significantly impact visitors' behavioral and emotional needs, as well as the complexity of the spatial layout. For instance, complex wayfinding systems may lead to mental fatigue, waiting rooms might increase patients' stress, and treatment rooms deprived of natural light could hinder patients' ability to relax during treatments.

This case study aims to map possible patient routes through various healthcare center functions and analyze the interactions between patients and architectural design characteristics. Simultaneously, through literature research, these functions will be evaluated concerning their impact on patients' mental health, leading to recommendations to include or exclude certain aspects in the design. Relevant architectural design features will be drawn from existing literature and applied solutions. While most available research is directed towards inpatient care facilities, stress-reducing features are presumed beneficial for both inpatient and outpatient care settings. To validate this, interviews, questionnaires, and a virtual reality (VR) model of a healthcare center will be employed.

Central to the literature on healthcare design and its positive effects on patient health is Ulrich's work (1991). Ulrich introduced the theory of supportive design in 1991 with the aim of reducing stress for inpatients. This theory hypothesises and confirms that an environment fostering perceptions of control (PC), positive distractions (PD), and social support (SS) — either individually or in combination — positively impacts patients' stress levels. The theory underscores the potential for environments to enhance outcomes and effectiveness in managing stress and promoting recovery mechanisms. Stress significantly affects health and the physical and mental recovery of patients, leading to numerous psychological, physiological, behavioral, and biochemical changes in the body and mind (Ulrich, 2003). However, Ulrich's theory explicitly excludes physically related stress factors, such as comfort and safety, which are pivotal in constructing healthcare centers, especially in safeguarding against infectious diseases.

## Problem statement

The surge in urbanization stands as one of the most significant health-related shifts in contemporary society, shaping our present and future. Presently, more than half of the global population resides in cities, a figure projected to rise to 70 percent by 2050. This accelerating urbanization exposes more individuals to social and physical environmental risks, such as poverty, traffic-related noise, and pollution. These factors contribute to both physical and mental stress, which indirectly impacts wellbeing overall (Gruebner, et al., 2017).

To mitigate these adverse effects, outpatient healthcare facilities, like healthcare centres, play a central role in preventing health issues. However, these facilities are under immense pressure due to a growing elderly population and a diminishing workforce. With limited capabilities for general practitioners to recruit and educate enough professionals, it becomes crucial to explore enhancing healthcare not only through technology, but also through architectural design.

Patients visiting healthcare centres encounter various modern-day stimuli that consume cognitive capacity, influencing their ability to focus. The constant information processing demands from everyday life, such as traffic, conversations, phones, work-related complexities, and decision-making, lead to mental fatigue (Kuo & Sullivan, 2001). Mental fatigue significantly impacts managing social situations, particularly potential conflicts, as it affects the processing of social cues, response evaluation, and enactment (Kuo & Sullivan, 2001). Environments, especially those involving nature, have rejuvenating effects and alleviate mental fatigue (Kuo & Sullivan, 2001).

Within healthcare centres, patients not only experience stress from daily life but also from their own health issues and anxieties, including social anxiety and personal safety concerns. The prevalence of social anxiety has notably risen, with up to one in three young individuals meeting social anxiety thresholds (Jefferies & Ungar, 2020). Patients grappling with social anxiety are more prone to stress in both public and private environments compared to others. This surge in social anxiety, combined with safety concerns regarding disease transmission, potentially contributes to increased aggression against healthcare personnel. Statistics reveal that healthcare centres face a notable risk of exposure to aggression, with 35% of incidents of all healthcare personnel occurring there, largely due to non-compliance (50%) and communication issues (27%) (Sari, Yildiz, Cagla Baloglu, Ozel, & Tekalp, 2023). While not all patients demonstrate increased stress levels through aggression, the statistics are an indication that there could be heightened stress levels in many more patients, impacting their compliance and communication with healthcare staff.

The recent COVID-19 pandemic highlighted the importance of architectural and technical designs in preventing viral transmission. Current HVAC installations and floorplan layouts often lack adequate protection against the transmission of airborne diseases, despite their potential capability. These structural elements, integrated into architectural design, can be challenging to modify when already constructed. Educating patients about pathogen-reducing installations may help alleviate anxiety.

This research aims to provide evidence-based design solutions for healthcare centres, to promote human-centric architecture that fosters health and wellbeing. Although the focus is on the healthcare center design at plot M3a in IJburg, Amsterdam, the outcomes could be relevant for any care center. Considering that environments encompass multiple features; it is essential to assess different design solutions' balance between overstimulation and understimulation.

The existing body of research on architectural characteristics and their impact on mental wellbeing primarily concerns the inpatient care environments, where patients are confined to their rooms for extended periods of time. Literature often discusses environmental control within patient spaces, including factors like windows and connections to other spaces promoting social interaction. In contrast, in healthcare centers, the environmental setting is predominantly controlled by healthcare professionals, limiting patient interaction. This research will examine architectural features that innately enhance wellbeing on a fundamental level, testing their efficacy in healthcare settings where patients have limited interaction with the environment.

Given risk exposure of a healthcare centre for aggressive incidents and the lack of applying stress reducing architectural characteristics for mental wellbeing in outpatient care. The aim of this paper is to determine how architectural features can reduce stress in healthcare centre patients, with the purpose of improving the patients experience and indirectly reducing risk of conflict. Therefore, the research question is: **'What architectural characteristics positively impact the users' experience of stress and safety in a healthcare centre?'**

*How do patients move through healthcare centres?*

*How can a healthcare centre mitigate mental and physical stress for patients?*

*What architectural characteristics can mitigate viral transmission?*

*Can the patients' experienced stress be reduced with greater architectural depth?*

*What does the data indicate for future architectural design of healthcare centres?*

The use of literature research and virtual reality (VR) testing holds significant merit in justifying design choices within healthcare environments. Literature research allows designers to ground their decisions in established principles and evidence, ensuring an understanding of how different design elements impact patient well-being. VR testing then becomes an essential tool in the practical validation of these choices. By immersing patients in simulated environments, designers can assess real-time reactions and gather valuable feedback to refine the design. This integrated approach not only strengthens the credibility of design decisions but also ensures that the final environment is optimized to meet the diverse needs of patients. In combining insights from literature research with the experiential feedback from VR testing, designers can iteratively refine healthcare spaces, ultimately creating environments that genuinely support positive patient experiences.

## How do patients move through healthcare centres?

The patient's journey within a healthcare center constitutes a sequence of events that begins when a patient first requires care and concludes once that need has been met (see Figure 1). This journey significantly impacts the stress experienced by the patient during their health care centre visit and ultimately influences the outcome of their experience (Qualtrics'XM, 2023)

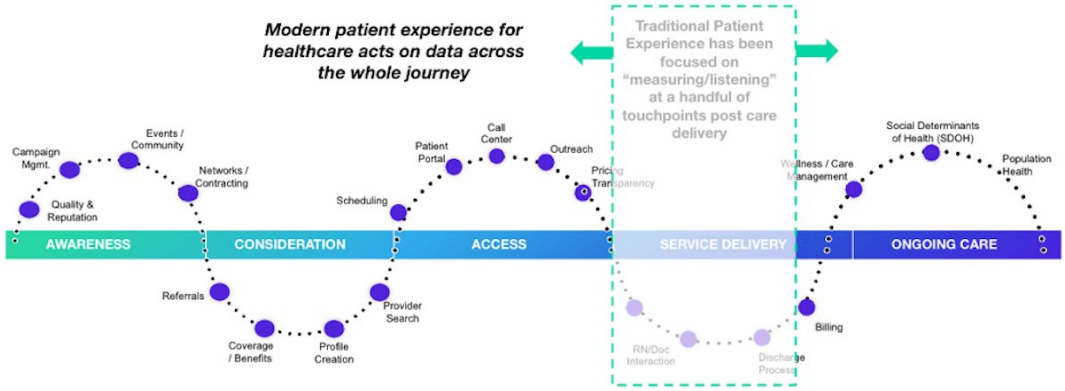


Figure 1 : Patient Journey (Qualtrics'XM, 2023) Image from website 2023-12-18)

The central phase of service delivery unfolds within the healthcare center, where each patient undergoes a unique experience shaped by their emotional state and sensory input. The degree of stress experienced, which profoundly influences the course of the visit, is affected by environmental factors. Architectural design elements and management practices, such as crowding, privacy, comfort, wayfinding, positive distractions, and safety, notably impact this experience. The patient navigates a defined sequence of spaces during their visit, each of which is subject to research regarding its impact on aspects of the patient's journey.

Typically, a patient progresses through specific spaces during their visit to a healthcare center, such as an entrance, a reception area, a waiting room, and various treatment spaces for physical and oral examinations. In some cases, a pharmacy is also included in the layout, as depicted in the visualization of the patient's journey (see Figure 2) within this case study.

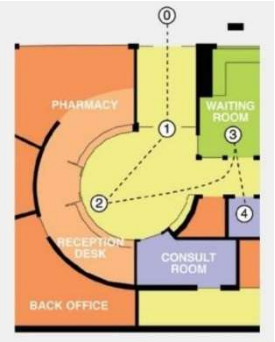


Figure 2 : HHC route (Willekens, Krabshuis, & Miedema, 2022)

The layout of spaces becomes increasingly complicated when various healthcare disciplines need separate waiting rooms and private consultation spaces. For instance, in the case study, the design brief outlines the inclusion of three full-time general practitioners and up to four distinct healthcare disciplines.

The patient's experience within a space heavily depends on their focus and attention. Even though some visitors may be constantly engaged with their phones, a patient primarily visits the healthcare center for medical attention. This journey involves interactions at the reception area with the staff, navigation to the designated waiting area, waiting in the specified area, and compliance with professionals' instructions. The physical spaces within the center accommodate these interactions through architectural characteristics, and the design of these architectural elements' constituents these interactions.

## What interactions do patients have in healthcare centres and how are they influenced by architectural design characteristics?

The mental and physical challenges patients face in relation to design characteristics are rooted in the needs they have in them. From entering the facility to navigating hallways to reach healthcare professionals, patients require spatial cognitive functioning. They engage with assistants, receptionists, and healthcare providers, or are waiting in waiting rooms until a professional attends to them. Beyond these interactions, local physical conditions such as noise, temperature, air quality, and lighting contribute to stress. Ulrich's supportive design theory identifies three key settings known to reduce stress, calm patients, and support coping resources and healthful processes (Ulrich, 2003).

Ulrich's research advocates for environments that foster these key settings, which significantly benefit patients. These three pillars are defined as: Sense of control, Social support, and Positive distractions. A sense of control results from people's perceived or actual ability to make decisions, influence situations, and determine interactions—a concept applicable from allowing individuals to adjust temperature to a patient's capability to orientate themselves, using wayfinding signage. Social support delves into patients' emotional states, encompassing care and support from those around them, extending to creating welcoming waiting areas and encouraging interaction among staff, patients, and visitors. Positive distraction serves as a rapid and effective stress-relief mechanism. While Ulrich (2003) initially outlined music, comedy, art, companion animals, and nature as positive distractions, recent studies indicate that a broad range of visually complex imagery, including nature-inspired geometric patterns, daylight, and various other visual stimuli, that can offer similar benefits.

## The Stress of Wayfinding (Perception of Control)

Inadequate wayfinding within a built environment can significantly contribute to heightened stress levels among occupants. Poor signage, confusing layouts, lack of visual cues, and complex navigation systems can all lead to increased frustration, anxiety, and a sense of disorientation. When individuals struggle to find their way or feel lost within a space, it can negatively impact their psychological well-being and overall experience. This stress-inducing environment highlights the critical importance of Ulrich's Supportive Design Theory. Ulrich's principles advocate for creating environments that prioritize human needs, including the promotion of stress reduction and well-being. By integrating intuitive wayfinding systems, clear signage, and easily navigable layouts, supportive design aims to mitigate the stress associated with navigating complex spaces, fostering a sense of comfort, control, and security for occupants. Ulrich's theory underscores the significance of designing spaces that not only cater to functional needs but also prioritize the mental and emotional well-being of individuals, ultimately enhancing the overall quality of their experience within a built environment.

## The Stress of Waiting (Positive Distractions)

Healthcare visits come with varied degrees of tension, deepened by concerns about whether providers will address the patients' problems. Waiting times, magnifying these anxieties, can lead to negative perceptions of care, even resulting in violence or aggression (Fryburg, 2021) For many patients, waiting becomes a form of indefinite distress, associated with emotions like anger, fear, and desperation. This distress is heightened when bureaucratic structures delay access to necessary medical help. The mental energy required to cope with anger, desperation, or fear contributes to mental fatigue, which in turn influences the patients capabilities to cooperate or communicate with healthcare personal.

## The Stress of Social Interaction (Social Support)

In unfamiliar and potentially stressful healthcare environments, social support from others can alleviate stress, fostering a sense of belonging, self-worth, and security (Andrade & Devlin, 2015). However, an increase in loneliness and associated social anxieties have made healthcare center visits increasingly stressful for a larger population, with over 1 in 3 young people meeting thresholds for social anxiety (Jefferies & Ungar, 2020). This anxiety, stemming from negative self-imagery, fear of evaluation, and biased information processing, heightens stress during social interactions.

In reception areas, patients are required to share medical situations in a semi-public setting to receive appropriate treatment. This can significantly stress socially anxious individuals, as observed in a 2008 study differentiating low and highly socially anxious people's self-awareness in public and private environments (George & Stopa, 2008). This study noted that highly socially anxious individuals displayed stronger reactions in public settings, directly linked to feelings of anxiety.

A sense of privacy is significantly influenced by the layout of medical treatment rooms and waiting areas. Physical boundaries, like desk orientation, influence patients' perception of personal space and territory (Namazian & Mehdipour, 2013). U-shaped waiting rooms commonly limit patients' choices for their personal territory and control of social interactions.

## The stress of safety in healthcare

People might feel afraid or hesitant to enter healthcare buildings during a pandemic due to various reasons. The primary concern revolves around the fear of contracting a virus, given that semi-public spaces bring together individuals from diverse locations, increasing the risk of exposure. Uncertainty, lack of control, and previous experiences of outbreaks in public areas contribute to this fear. Additionally, conflicting information, vulnerability of certain demographics, social pressures, and adherence to government guidelines impact individuals' decisions. Addressing these concerns involves clear communication of safety protocols, ensuring

proper hygiene measures, and implementing visible precautions to build trust and alleviate fears about entering healthcare buildings during a pandemic.

### Physical stress (comfort)

The human body is susceptible to diseases and disorders due to external stress factors affecting various bodily systems, notably the nervous, endocrine, and immune systems. These factors encompass a range of influences such as the effects of external conditions (like fatigue and irritation), psychological impacts (including anxiety and depression), and stressors related to human senses (such as temperature extremes, odors, and noise). The level of discomfort varies across organs, ranging from mild discomfort to systemic allergic reactions, stinging sensations, infections, and even critically toxic effects (Fabbri, 2015).

The stress factors experienced within buildings stem from the regulated and controlled indoor environment, directly influencing people's mental well-being. A literature review conducted by Al horr et al. (2016) identified several facets of indoor environmental quality that significantly impact mental well-being. These factors include Indoor Air Quality (IAQ), thermal comfort, acoustic comfort, and visual comfort (Al horr, et al., 2016).

## How can architectural characteristics in a healthcare centre mitigate mental and physical stress for patients?

### Easing wayfinding (perception of control)

Efficient spatial cognitive functioning can be facilitated through wayfinding strategies, beginning with the clear identification of the building's entrance, ensuring the reception area's visibility upon entry, and providing clear directions from the reception to the appropriate waiting rooms and healthcare professionals' chambers. Wayfinding challenges are frequently documented in complex facilities such as airports, hospitals, and office buildings. Elements within the physical environment—such as landmarks, nodes, floor plan configurations, and environmental cues like signs and maps—contribute to aiding wayfinding (Jamshidi, Ensafi, & Pati, 2020).

Individual spatial navigation abilities vary, but research by Schmitz (1997) indicates that anxiety generally impacts spatial memory. Higher anxiety levels tend to prompt individuals to recall more landmarks than directions, suggesting distinct brain processes involved in navigation using maps or points of recognition (Jamshidi, Ensafi, & Pati, 2020). Other studies have revealed that in emergency and stressful situations, individuals often tend to prefer brighter corridors over wider ones at T and F-type intersections when no signs are available. Furthermore, during emergencies, people may not necessarily follow exit signs but opt for brighter corridors (Jamshidi, Ensafi, & Pati, 2020). In terms of signage, research suggests that colored trails on floors combined with wall-mounted, color-coded signage panels prove most effective in guiding individuals, resulting in reduced travel distances, increased speed, fewer pauses, and shorter completion times. The complexity of a floor plan directly impacts wayfinding performance (Jamshidi, Ensafi, & Pati, 2020).

In practical application, reducing floor plan complexity for patients can involve minimizing decision points, favoring a one-way route. The starting point of the route should serve as a prominent cognitive landmark, while incorporating unique landmarks and colored trails on both floors and walls can significantly aid navigation at critical nodes. Emergency exits should be well-lit and sufficiently wide.

### Offering privacy and territory (Social Support)

Privacy, as observed in environmental psychology, represents a fluid boundary between self and others—a regulatory process where individuals or groups may seek either separation or connection. Prolonged periods of solitude or excessive social interaction are both deemed undesirable states (Namazian & Mehdipour, 2013).

Environmental design aims to accommodate this alternation between separation and unity, with architects possessing a keen understanding of this delicate balance.

Perceptions of privacy boundaries are significantly influenced by societal norms, encompassing cultural variations and evolving social trends over time. Neglecting or rigidly implementing privacy in spatial design can lead to misunderstandings or a mismatch with people's perceived appropriateness of personal space and territoriality. Namazian & Mehdipour advocate that clearly defined territories contribute to smoother social interactions. Modern designers predominantly rely on participation and adaptability to establish the desired spatial context. Adaptability is demonstrated through movable walls that offer users control over their privacy and territoriality. However, these movable walls often remain stationary once set up by designers. Despite this issue, architects and planners advocate for new forms of adaptability that empower users to manage their physical environments (Namazian & Mehdipour, 2013).

In outpatient care settings, the 'patient' is frequently not the primary 'user.' Thus, spatial layouts tailored to medical professionals' perceptions of privacy boundaries might not align with patients' preferences. Studies suggest that public settings typically maintain approximately four feet of social distance among strangers, as indicated by Gordon in 1997. However, personal space can adapt based on circumstances, yet physical barriers, such as desks, might create fixed relationships where visitors can assume only one seating position. The literature advocates for offering multiple configurations or involving the individuals in design decisions (Namazian & Mehdipour, 2013).

For healthcare centers, this necessitates waiting rooms to provide various configurations, allowing patients to choose their preferred territory, contrary to rigid U or I-shaped setups. Moreover, involving not only physicians but also future patients in designing their healthcare centers fosters a more patient-centric approach.

## Effortless visual distraction (Positive Distraction)

In healthcare settings, the advantages of positive distraction are extensively recognized. Positive distractions redirect individuals' attention away from discomfort and anxiety. Within environmental psychology-based literature, static stimuli such as reading materials, photographs, and representational nature-themed posters or paintings are acknowledged as effective positive distractions (Andrade & Devlin, 2015). However, biophilic design, rooted in psychological research, explores the architectural application of positive distractions in greater depth. Biophilic design emphasizes 'patterns' that attract attention, inducing either stimulation or calmness while evoking a sense of time, weather, and the presence of living, or non-living organisms.

Among the 14 biophilic design patterns, one highlights visual connections with nature, observed in natural scenes featuring water, vegetation, animals & insects, terrain, and fossils. These elements can be translated directly into architectural design solutions, incorporating water features like aquariums, green walls, nature-themed artwork, videos, designed landscapes, and ornamental architectural elements representing amongst other, fossils. Other ‘patterns’ encompass dynamic light, referring to changing shadows, as well as biomorphic forms, characterized by contoured, patterned, textured, or numerical arrangements inspired by nature. Furthermore, material connections to nature, complexity and order relating to natural geometries, symmetries, and fractal dimensions, even providing prospect – offering relaxing views of people navigating areas, such as from a balcony – are included (Browning, Ryan, & Clancy, 2014).

The emphasis on the representation of 'nature' in research has reignited the 'nature vs. nurture' discussion. Neuro-architecture aims to identify human preferences across diverse participant groups differing in education, culture, and design expertise, utilizing brain imaging to mitigate for unconscious biases. For instance, Palumbo, et al., 2020 discovered that curved walls are universally preferred across various social and cultural groups, while familiarity with design expertise moderates this effect. Notably, individuals with autism were particularly positively influenced by curved designs. Considering that individuals function better in

environments they prefer, the adoption of curved interiors in new designs could foster autism-friendly spaces, promoting inclusivity (Palumbo, et al., 2020).

The extensive applicability of visual complexity turns entire buildings into a blank canvas. However, focusing on areas where patients spend about three to five minutes, or just a few minutes for acutely stressed patients, as it is crucial for them to fully experience and benefit from the designed environment. (Ulrich, 2003)

## External stress relief (Comfort)

Indoor environments can subject individuals to physical stressors such as poor air quality, thermal discomfort, acoustic disturbances, and visual challenges. Fortunately, these factors are often controllable within building structures. Over the past decades, building codes and standards have been established based on extensive research into human comfort. However, achieving an ideal built environment often involves trade-offs between these aspects, although considerable room for adjustments exist within benchmark values.

### Indoor Air Quality

Indoor air quality hinges on two primary systems: ventilation and pollution. Adequate ventilation ensures a sufficient and clean air supply within indoor spaces. Pollution sources indoors typically stem from occupants, equipment (e.g., printers), and building materials. Modern green building guidelines emphasize the use of low-polluting materials (Al horr, et al., 2016) contributing to a healthier indoor air quality over the long term. These eco-friendly materials possess moisture buffering and breathable properties that help mitigate moisture-related respiratory ailments by reducing airborne pollutants like mold, dust mites, allergens, and viruses.

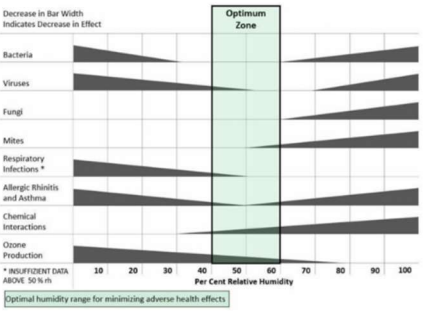


Figure 3 : Optimal humidity range for minimizing adverse health effects (Syriani, 2021)

### Thermal Comfort

The indoor thermal climate is often regulated by heating and cooling systems, or passively through techniques such as utilizing thermal mass or incorporating openings to the external environment. Fanger's comfort model (1967, 1970) predicts the 'Predicted Mean Vote' (PMV) and 'Predicted Percentage of Dissatisfied' (PPD) by considering factors like metabolism, clothing insulation, airspeed, and humidity. This widely applied theory has been incorporated into building codes with some refinements.

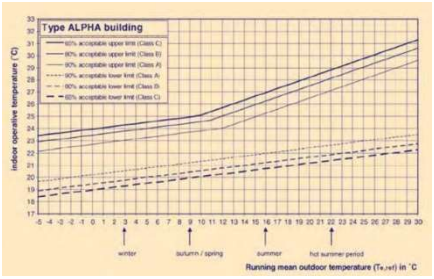


Figure 4 : Fanger comfort model

### Acoustic Comfort

Indoor noise, mostly stemming from external sources, often conflicts with the need for fresh air circulation in buildings. Inadequate acoustic comfort can provoke irritation, aggressiveness, reduce physical and mental performance, disrupt sleep, alter behavior, and cause discomfort, headaches, and other health issues (World Health Organisation, 1990). Indoor noise can also pose problems as well; for instance, long reverberation times in rooms can impede communication. Determining reverberation time involves considering finish materials, space geometry, and interior elements such as drapes, furniture, and occupants.

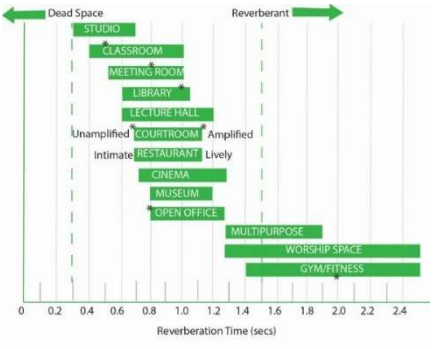


Figure 5 : Target value reverberation time (Eguez, 2017)

### Visual Comfort

Visual comfort centers on users' physical sight needs and differs from positive distractions. However, individual visual capabilities vary, prompting the development of standards for universally accepted values. Assessment of the visual baseline incorporates parameters like daylighting, illuminance levels, and glare, contributing to a high-quality indoor environment. Yet, personal comfort is dependent on adaptability, influenced by lighting controllability, outside views, and anti-glare measures (Giarma, Tsikaloudaki, & Aravantinos, 2017). The level of illuminance deemed comfortable depends on the specific tasks' individuals need to accomplish, typically indicated in lumen/m².

| Illuminance - Recommended Indoor Light Levels | |
|---|---|
| **Activity** | **Illuminance** *(lx, lumen/m²)* |
| Public areas with dark surroundings | 20 - 50 |
| Simple orientation for short visits | 50 - 100 |
| Areas with traffic and corridors - stairways, escalators and travelators - lifts - storage spaces | 100 |
| Working areas where visual tasks are only occasionally performed | 100 - 150 |
| Warehouses, homes, theaters, archives, loading bays | 150 |
| Coffee break room, technical facilities, ball-mill areas, pulp plants, waiting rooms, | 200 |
| Easy office work | 250 |
| Class rooms | 300 |
| Normal office work, PC work, study library, groceries, show rooms, laboratories, check-out areas, kitchens, auditoriums | 500 |
| Supermarkets, mechanical workshops, office landscapes | 750 |
| Normal drawing work, detailed mechanical workshops, operation theaters | 1000 |
| Detailed drawing work, very detailed mechanical works, electronic workshops, testing and adjustments | 1500 - 2000 |
| Performance of visual tasks of low contrast and very small size for prolonged periods of time | 2000 - 5000 |
| Performance of very prolonged and exacting visual tasks | 5000 - 10000 |
| Performance of very special visual tasks of extremely low contrast and small size | 10000 - 20000 |

Figure 6 : Recommended indoor light levels (The Engineering Toolbox, 2023)

## Architectural characteristics that mitigate viral transmission.

As society evolves and safety standards change, constructing buildings that foresee future needs becomes paramount to minimizing necessary interventions for operational efficiency. The emergence of Covid-19 has accentuated the importance of indoor building safety, particularly in healthcare. Addressing transmission-proof spatial design and HVAC (heating, ventilation, and air conditioning) concerns, anticipating future occupancy changes, and evaluating sustainable requirements for healthcare centers are critical considerations (Zang, Kin Peng Hui, Duffield, & Saeed, 2022)

### Transmission-Safe Spatial Design

Control of occupant density within spaces significantly impacts virus exposure and physical interactions. Implementing one-way movement pathways and automated doors minimizes physical contact, especially crucial in healthcare settings where infectious patients receive treatment. The patient's route should ideally split post-reception to direct to specific healthcare professionals and direct to a dedicated exit separated from the entrance.

### Transmission-Safe Occupancy and Use

Managing indoor occupancy can limit interactions between different groups, reducing the risk of disease transmission. Respiratory (breathing, whispering, singing, speaking) and physical activities impact particle dispersion in the atmosphere; building functions and HVAC systems can mitigate this risk. The digitalization of work environments, though not yet proven more productive than face-to-face interactions, may lead to reduced spatial occupancy for healthcare centres, but increasing space needed for technology and secure data communication. (Zang, Kin Peng Hui, Duffield, & Saeed, 2022)

### Transmission-Safe HVAC

Environmental conditions like humidity, temperature, ventilation rate, sunlight, and airflow velocity influence airborne microbe survival (Zang, Kin Peng Hui, Duffield, & Saeed, 2022). Building systems designed for controlled indoor environments may employ air purification filters to manage indoor air quality, although typical pollution filters may not capture virus particles like HEPA filters. However, HEPA filters require more frequent replacement and increased system power consumption.

Improving airflow circulation by increasing outside air supply, ventilation rates, and pressure differentials between rooms can significantly reduce transmission risk. Optimizing airflow patterns within buildings through positive and negative pressurization has shown promise, but practical implementation challenges remain, while also impacting spatial adaptability and functionality.

Daylight, with its inherent ability to reduce virus activity and disinfect surfaces through ultraviolet light exposure, offers a natural defense against infections. Ultraviolet germicidal irradiation (UVGI) systems, used in hospitals for tuberculosis prevention, demonstrate effectiveness in reducing airborne microorganisms.

### Communicating transmission safety to reduce anxiety.

To alleviate anxiety for visiting patients in a healthcare setting amid concerns about viral transmission, tailored communication strategies are essential. Clear signage, patient-friendly educational materials, and a dedicated website section should reassure patients about the safety measures in place. Personalized emails, newsletters, and virtual open houses or webinars could offer direct communication channels to explain these measures, address concerns, and highlight success stories. Collaboration with patients advocate and the incorporation of interactive virtual tours can further enhance patient understanding and confidence. Continuous updates, feedback channels, and personalized consultations with healthcare professionals contribute to transparent communication, building trust, and ensuring patients feel secure and cared for during their visits.

## Can the patients experienced' stress be reduced with greater architectural depth?

### Enhancing Architectural Depth for Patient Well-being

Architectural depth, defined by the number of spaces traversed between rooms, buffers against crowding-induced psychological distress (Evans, Lepore, & Schroeder, 1996). In healthcare centres, patients move through multiple spaces from reception to healthcare provider, and by increasing architectural depth space can be created to incorporate functions that reduce patient stress.

Beyond traditional healthcare spaces, the addition of healing gardens or outdoor areas, meditation or quiet rooms, art and music therapy spaces, family support areas, multi-sensory rooms, and fitness or exercise areas can contribute to stress reduction and overall well-being for patients. These spaces offer opportunities for connection with nature, creative expression, social support, and sensory experiences, fostering a holistic approach to healing. The incorporation of natural light, views of the outdoors, and technology-driven relaxation features further aligns with the principles of Ulrich's theory, creating environments that prioritize patient comfort, positive distraction, and improved overall patient experiences in healthcare settings.

In addition to features aligned with Ulrich's Supportive Design Theory, healthcare facilities can incorporate various functions to enhance the overall patient experience and support comprehensive care. This may include designated spaces for patient education, telehealth or virtual care, flexible-use areas for events and support groups, community outreach centres for health initiatives, integrated cafes or nourishment spaces, wellness and fitness centres, collaborative workspaces for healthcare professionals, advanced imaging centres with state-of-the-art technology, and recovery spaces for post-procedure care. These functions aim to address diverse aspects of patient well-being, engagement, and convenience, creating a multifaceted healthcare environment that goes beyond the physical setting to meet the evolving needs of patients, families, and healthcare professionals within the facility.

### Applying architectural depth in architectural functions

Architectural depth in healthcare centres alleviates crowding-induced psychological distress by increasing the spaces between rooms. This allows for the integration of functions that reduce patient stress during movement. In addition to traditional healthcare spaces, incorporating healing gardens, outdoor areas, meditation rooms, art and music therapy spaces, family support areas, multi-sensory rooms, and fitness areas contributes to stress reduction and overall well-being. These elements foster a holistic approach to healing by facilitating nature connection, creative expression, social support, and sensory experiences. Aligning with

supportive design principles, the integration of natural light, outdoor views, and technology-driven relaxation features prioritizes patient comfort. Expanding healthcare facilities to include spaces for patient education, telehealth, flexible-use areas, community outreach centres, integrated cafes, wellness and fitness centres, collaborative workspaces, advanced imaging centres, and recovery spaces creates a comprehensive and adaptable healthcare environment meeting diverse needs.

## What does the data indicate for future architectural design of healthcare centres?

### Recommendations for efficient spatial cognitive functioning and wayfinding in healthcare settings:

- Clear Entrance Identification: Ensure clear identification of the building's entrance to facilitate efficient wayfinding for patients.
- Visible Reception Area: Make the reception area visible upon entry to guide patients smoothly into the healthcare facility.
- Directional Guidance: Provide clear directions from the reception to relevant waiting rooms and healthcare professionals' chambers, minimizing confusion.
- Utilize Landmarks and Nodes: Incorporate prominent landmarks and nodes within the facility's physical environment to aid wayfinding and enhance spatial navigation.
- Consider Environmental Cues: Use environmental cues such as signs, maps, and floor plan configurations to assist individuals in navigating complex healthcare facilities.
- Address Wayfinding Challenges: Recognize and address wayfinding challenges that are commonly documented in complex facilities like hospitals, aiming to improve overall spatial cognitive functioning.
- Minimize Decision Points: Reduce floor plan complexity for patients by minimizing decision points and favouring one-way routes, simplifying navigation.
- Color-Coded Signage: Implement color-coded signage panels, combined with coloured trails on floors and walls, for effective wayfinding, reducing travel distances and completion times.
- Well-Lit Emergency Exits: Ensure emergency exits are well-lit and sufficiently wide, recognizing that people may prefer brighter corridors over wider ones during stressful situations.

### Recommendations on spatial design and privacy considerations in healthcare:

- Dynamic Perception of Privacy: Recognize privacy as a dynamic concept with a fluid boundary between self and others, understanding that individuals or groups may seek alternation between separation and connection.
- Consideration of Societal Norms: Acknowledge the significant influence of societal norms, cultural variations, and evolving social trends on perceptions of privacy boundaries in spatial design.
- Avoiding Rigidity: Avoid rigidly implementing privacy in spatial design to prevent misunderstandings or mismatches with people's perceived appropriateness of personal space and territoriality.
- Clearly Defined Territories: Recognize that clearly defined territories contribute to smoother social interactions, emphasizing the importance of understanding and respecting personal boundaries in design.
- Adaptability in Design: Emphasize adaptability in design, such as through movable walls, to empower users with control over their privacy and territoriality, fostering a sense of autonomy.
- User Involvement in Design: Involve users, including both medical professionals and patients, in the design process to ensure that spatial layouts align with preferences and needs.
- Consideration of Patient Preferences: Recognize that in outpatient care settings, patients may not always be the primary users, and spatial layouts should consider both medical professionals' and patients' perceptions of privacy boundaries.

- Flexible Configurations in Waiting Rooms: Design waiting rooms in healthcare centres with various configurations, allowing patients to choose their preferred territory, moving away from rigid U or I-shaped setups.
- Adaptation to Social Distancing: Be adaptable to social distancing norms and consider providing configurations that allow for appropriate personal space while also accommodating changing circumstances.
- Patient-Centric Approach: Foster a patient-centric approach in healthcare centre design by involving not only physicians but also future patients in the design process, ensuring that the spatial layout aligns with their needs and preferences.

## Recommendations on positive distractions and stress reducing design:

- Incorporate Positive Distractions: Recognize the advantages of positive distractions in healthcare settings to redirect individuals' attention from discomfort and anxiety.
- Use Static Stimuli: Utilize static stimuli such as reading materials, photographs, and nature-themed posters or paintings as effective positive distractions in healthcare environments.
- Explore Biophilic Design: Embrace biophilic design, which is rooted in psychological research, and explores the architectural application of positive distractions by emphasizing patterns that attract attention and induce stimulation or calmness.
- Visual Connections with Nature: Implement architectural solutions that create visual connections with nature, incorporating elements such as water features, green walls, nature-themed artwork, videos, designed landscapes, and ornamental architectural elements.
- Dynamic Light and Biomimicry: Consider the inclusion of dynamic light, changing shadows, biomorphic forms, and material connections to nature, as these contribute to the positive impact of biophilic design.
- Nature-Inspired Geometries: Integrate natural geometries, symmetries, and fractal dimensions into architectural design, promoting a sense of order and complexity inspired by nature.
- Incorporate Prospect: Design spaces that offer relaxing views, such as from a balcony, allowing individuals to navigate areas and experience a sense of prospect within the environment.
- Consider Neuro-Architecture: Explore neuro-architecture to identify human preferences across diverse participant groups, using brain imaging to mitigate unconscious biases and informing design choices.
- Universal Design Preferences: Recognize universal design preferences, such as the preference for curved walls across different social and cultural groups and consider incorporating these features in architectural designs to enhance inclusivity.
- Tailor Visual Complexity: Focus on areas where patients spend a substantial amount of time to fully experience and benefit from the designed environment, emphasizing the importance of tailoring visual complexity in specific spaces within healthcare settings.

## Recommendations on indoor comfort levels:

- Indoor Air Quality:
    - Prioritize adequate ventilation systems to ensure a clean and sufficient air supply within indoor spaces.
    - Emphasize the use of low-polluting materials in accordance with modern green building guidelines to contribute to healthier indoor air quality.
    - Choose eco-friendly materials with moisture buffering and breathable properties to mitigate respiratory ailments related to airborne pollutants.
- Thermal Comfort:
    - Regulate the indoor thermal climate through effective heating and cooling systems or passive techniques like thermal mass and openings to the external environment.

    - Consider Fanger's comfort model, incorporating factors such as metabolism, clothing insulation, airspeed, and humidity, to predict and achieve thermal comfort in line with building codes.
- Acoustic Comfort:
    - Address indoor noise issues, often stemming from external sources, to prevent irritation, aggressiveness, and health issues.
    - Recognize that inadequate acoustic comfort can disrupt sleep, alter behaviour, and impact physical and mental performance.
    - Consider factors such as reverberation time, finish materials, space geometry, and interior elements to optimize acoustic comfort.
- Visual Comfort:
    - Assess and enhance visual comfort by considering parameters like daylighting, illuminance levels, and glare in the indoor environment.
    - Implement lighting controllability, provide outside views, and incorporate anti-glare measures to cater to individual visual capabilities.
    - Recognize that personal comfort depends on adaptability influenced by lighting conditions and specific tasks individuals need to accomplish.
- Trade-offs and Adjustments:
    - Acknowledge that achieving an ideal built environment often involves trade-offs between aspects like air quality, thermal comfort, acoustic conditions, and visual comfort.
    - Emphasize the considerable room for adjustments within benchmark values to optimize the indoor environment based on specific needs and preferences.

## Recommendations on viral transmission safety:

- Transmission-Safe Spatial Design:
    - Implement one-way movement pathways and automated doors to minimize physical contact and reduce virus exposure.
    - Design patient routes post-reception that split to direct them to specific healthcare professionals and a dedicated exit separated from the entrance.
- Transmission-Safe Occupancy and Use:
    - Manage indoor occupancy to limit interactions between different groups and reduce the risk of disease transmission.
    - Consider the impact of respiratory and physical activities on particle dispersion and explore ways building functions and HVAC systems can mitigate these risks.
- Transmission-Safe HVAC:
    - Optimize environmental conditions like humidity, temperature, ventilation rate, sunlight, and airflow velocity to influence airborne microbe survival.
    - Explore the use of air purification filters, such as HEPA filters, while considering their maintenance and power consumption requirements.
    - Improve airflow circulation by increasing outside air supply, ventilation rates, and pressure differentials between rooms to reduce transmission risk.
    - Explore the potential of daylight and ultraviolet germicidal irradiation (UVGI) systems to naturally reduce virus activity and disinfect surfaces.

### Communication Strategies:

- Tailor communication strategies to alleviate anxiety for visiting patients in healthcare settings regarding viral transmission.
- Use clear signage, patient-friendly educational materials, and a dedicated website section to reassure patients about implemented safety measures.
- Utilize personalized emails, newsletters, and virtual open houses or webinars for direct communication to explain safety measures, address concerns, and highlight success stories.

    - Collaborate with patient advocates and incorporate interactive virtual tours to enhance patient understanding and confidence.
    - Maintain continuous updates, feedback channels, and personalized consultations with healthcare professionals for transparent communication, building trust, and ensuring patient security and care during visits.

## Recommendations for increasing well-being through the addition of architectural functions:

- Increase Architectural Depth:
    - Consider increasing architectural depth in healthcare settings to buffer against crowding-induced psychological distress, creating a more spacious and stress-reducing environment for patients.
- Diverse Healing Spaces:
    - Integrate diverse healing spaces beyond traditional healthcare settings, including healing gardens, outdoor areas, meditation or quiet rooms, art and music therapy spaces, family support areas, multi-sensory rooms, and fitness or exercise areas.
    - These spaces offer opportunities for connection with nature, creative expression, social support, and sensory experiences, fostering a holistic approach to healing.
- Natural Elements and Technology-Driven Features:
    - Incorporate natural light, views of the outdoors, and technology-driven relaxation features to align with principles supporting patient comfort, positive distraction, and improved overall patient experiences, as proposed by Ulrich's theory.
- Supportive Design Theory:
    - Align with Ulrich's Supportive Design Theory to create environments that prioritize patient comfort, positive distraction, and improved overall patient experiences in healthcare settings.
- Comprehensive Care Functions:
    - Integrate various functions into healthcare facilities to enhance the overall patient experience and support comprehensive care.
    - Include designated spaces for patient education, telehealth or virtual care, flexible-use areas for events and support groups, community outreach centres for health initiatives, integrated cafes or nourishment spaces, wellness and fitness centres, collaborative workspaces for healthcare professionals, advanced imaging centres, and recovery spaces for post-procedure care.
- Multifaceted Healthcare Environment:
    - Develop a multifaceted healthcare environment that goes beyond the physical setting, addressing diverse aspects of patient well-being, engagement, and convenience.
    - Cater to the evolving needs of patients, families, and healthcare professionals within the facility by incorporating a variety of functions and spaces.

## Discussion

The impact of environments on human mental state are limited, an environment does not overwrite what people are occupied with in their heads. Claudia and Ann researched this in 2014, they measured stress levels comparing a generic environment with an environment with positive features. For 217 participants, on a scale of 4, the change between all amenities and none was about 0.5, so about 12.5% of experienced stress would be reduced by the interventions. However, if this translates in 12.5% less aggressive incidents in healthcare centres would need to be studied over a long period of time.

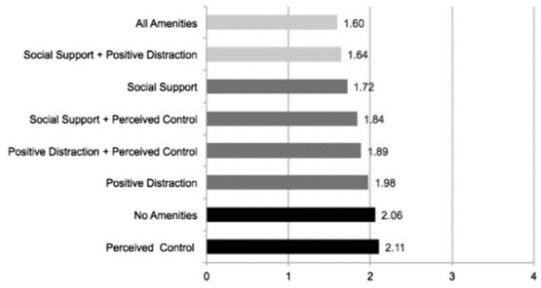


**Fig. 3.** Level of expected stress by condition (0 = not al all, 4 = very much). Means in light grey and black bars are significantly different from each other.

The practicality of curved rooms can be discussed, the majority of building materials is shaped for angular use in order to shape these to be curved might lead to additional material use or working hours. Future research in financial gain versus achieved stress reduction. 3D printing of walls could however make this more viable.

By applying architectural depth, a floorplan could increase in complexity, this floorplan complexity could potentially increases the stress levels of the users. For a designer using this strategy it is important to balance these stress reducing qualities.

Discussion points as set by professor in architecture: “How do you deal with the synthesizing quality achieved through architectural design? It is one thing to study isolated qualities or elements that benefit (or not) to health, but in architecture we are as much concerned with bringing various qualities together into one integrated plan. How could you incorporate that in at least the design part of your project?”
As listed in the recommendations following the research, many isolated qualities or elements have been listed. In order to apply my research, I found that I needed to cluster the different architectural functions on the basis of why people visited a specific part of the building, for example the offices separated from the treatment rooms or waiting rooms. This created the opportunity to apply different architectural characteristics to the different clusters that fit the stress reducing qualities of that ‘type’. These different qualities lead to a more ‘patchwork’ like architecture, corresponding with the nature of the context. My experiences have led me to think that applying environmental psychology principles in architectural conceptual design are most applicable in single purpose buildings, like churches or museums.

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