The role of view and daylight on visual perception of people

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1. Introduction

Health is a combination of physical, mental and social wellbeing, not solely based on diseases or infirmity. In health care facilities (hospitals) people go to get treated by medical specialists in their respected fields of expertise. In these health care facilities, the design of the building is highly influenced by the type of treatment performed on the patients. Therefore, the design often lacks in other aspects of people health. Especially in older health care facilities, the mental and social wellbeing of the patient were not taken in to account in the design. This was partially due to the fact that the information on social and mental wellbeing of patients was lacking. Since the connection between visual landscape and a person wellbeing was brought to people's attention by the paper: "Visual landscapes and psychological well-being", written by Ulrich, more research focused on social and mental wellbeing of people in regard to connection to the outside. (Huisman, Morales, van Hoof, & Kort, 2012) (Ulrich R. S., 1978)

In the paper Ulrich mentions that the notion of exposure to nature as being psychologically helpful is ancient. He went further, by testing the effect of 2 different landscape views on the psychological well-being of the people. The test results suggest that stressed people feel significantly better after watching nature views compared to views composed solely out of buildings. It even showed that the view of composed solely out of buildings decreased the psychological well-being of people, and it even increased the feeling of sadness. Therefore, the conclusion from the test were that outdoor visual environment matters and more attention should go to it, since the outdoor visual environment has influence on people psychological well-being. (Ulrich R. S., 1978)

Ulrich's revolutionary paper was the starting point for designing health care facilities that focus on the influence of the physical environment on people's mental and social wellbeing. This design process of health care facilities is called evidence-based design (or healing environment). Since the paper, an increasing body of knowledge on evidence -based design has become available and is still increasing at the point in time this graduation paper is written. However, research on many topics in this field is still lacking. For people with poorer physical conditions, for whom the psychological well-being is of key importance, factors influence such well-being can be life changing. Among these factors, the visual environment plays a large role. However, a lot of ground still need to be covered when it comes to pinpointing relevant factors and their exact effect. This report will explore the effect of the visual environment on hospital patients. In particular, it will identify which factors, among those related to the view to the outside and to daylight parameters, influence the visual perception of people.

2. Context

The Erasmus MC built in Rotterdam built in recent years several roof gardens (Geest, 2020), with evidence- based designing of the hospital as main motive. The roof gardens are linked to the mental/physical wellbeing of patients by providing view towards nature from the respective patent rooms.

The view to the outside in patient rooms has an influence on the rehabilitation during their stay. (Shepley, Gerbi, Watson, Imgrund, & Sagha-Zadeh, 2012)However, the information on the quantitative and qualitative factors of the view outside and their interplay with daylight access is still lacking.

The Greenview project is a collaborative research team between the Technical University of Delft and the Erasmus MC, which aims to collect robust evidence on the topic of evidence-based design of hospital roof gardens. These roof gardens should have a positive effect on hospital patient rehabilitation and reduce the length of stay. The Greenview project mainly focus on quantitative and qualitative factors of the view to the outside and the effects of the daylight parameters in patient rooms. This graduation project paper has taken the information gathered and retrieved from the Greenview project and analysed it, to unveil the influence of the view factors and daylight parameters on the visual perception of people.

3. Background research

To get a better grasp on this relative broad topic, research had to be done on the available literature information on the topic. First an orientation of the existing building norms regarding daylight in buildings through windows had to be done, starting from the NEN-EN 17037. Then, to get a better understanding of the general design patient room, articles were found by using “evident based design” and “hospital design “as keywords. For further information on the possible factors on the view to the outside articles were found which described tests which relate to either relevant view factors or daylight factors. These articles were found by using keywords like,” daylight research + wellbeing” and “view factors + wellbeing”. Other articles were found by looking into articles from relevant journals such as, Lighting Research & Technology.

3.1 NEN-EN 17037 daylight in buildings

The NEN-EN describes: “basic, minimum functional requirements and recommendations for an accessible and usable built environment, following "Design for All"/"Universal Design" principles which will facilitate equitable and safe use for a wide range of users, including persons with disabilities.” (Accessibility and usability of the built environment - Functional requirements, 2021)

The NEN-EN used in this research paper (NEN-EN 17037) covers the daylight requirements and recommendations in buildings. The NEN-EN 17037 is divided into several aspects, for each aspect the criteria are explained to reach the minimum functional requirement and recommendation. The aspects in the NEN-EN 17037 are the following: daylight provision, view out, exposure to sunlight and protection from glare.

From the NEN-EN 17037 a few criteria could be derived which were relevant to the research topic. First the factors which need to be considered when designing view quality for a single point in the room, looking outwards. These factors are the following: the size of the daylight opening, the width of the view, the outside distance of the view, the number of layers and the quality of the environment information of the view.

The view factors concerning the area which is seen throughout the entire window view are considered adequate when the glazing for the view is uncoloured and undistorted /clear, the distance the outside view point should be larger than the minimum value of 6 meters, in the utilized area at least a landscape layer should be present. (NEN-EN 17037+A1, 2021)

To determine the view quality 2 methods can be used, the simple and the advanced verification method. The simplified verification method only considered a fixed view line to the outside, which can be seen in figure 1. The advance verification method which makes use of a projection calculation, used for multiple view areas, can be seen in figure 2.

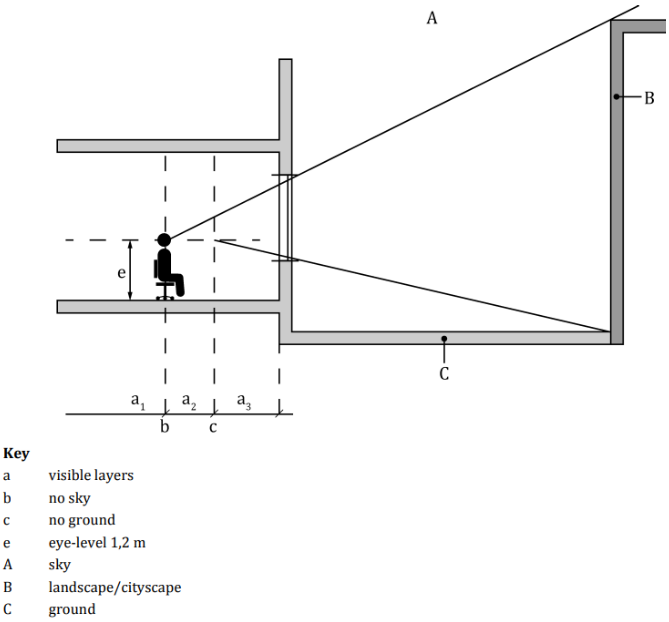
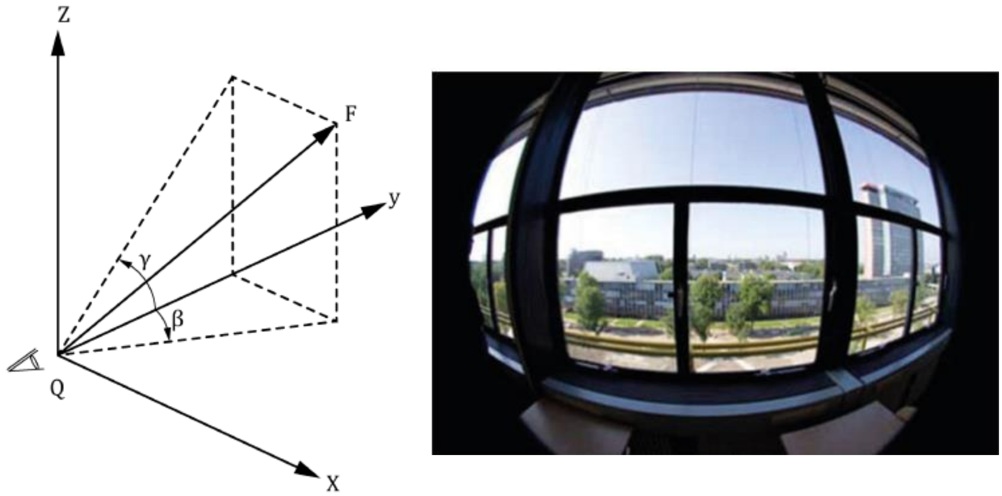


Figure 1 View out, simple verification method. (NEN-EN 17037+A1, 2021)



Key

y viewing direction

Q eye-level

F the location where an object is observed

Figure 2 View out, advance verification method. (NEN-EN 17037+A1, 2021)

Sunlight is essential to any interior area for in particular houses, care homes and hospitals. The optimal amount, duration and time of sunlight is depended on the function of the space. To evaluate the sunlight exposure in an interior space, some aspects of the sun compared to the space need to be known, such as the sun visibility during specific dates and the number of hours during which the room is illuminated by direct sun.

When the amount of sunlight is properly monitored and controlled it has positive effects on the interior space and the people present. Therefore the extreme ends of the sunlight intensities can have negative influence on the space and the people present, so exclusion or too much excess of sunlight need to be avoided for most functions.

For daylight factors, table 1 shows the factor values for minimum, medium and high level of recommended daylight. Table 2 shows the recommend values for sunlight per day.

Table 1 recommendation of daylight provision. (NEN-EN 17037+A1, 2021)

Level of recommendation for vertical and inclined daylight opening	**Target illuminance** E_T lx	**Fraction of space for target level** $F_{plane,\%}$	**Minimum target illuminance** E_{TM} lx	**Fraction of space for minimum target level** $F_{plane,\%}$	**Fraction of daylight hours** $F_{time,\%}$
Minimum	300	50 %	100	95 %	50 %
Medium	500	50 %	300	95 %	50 %
High	750	50 %	500	95 %	50 %
NOTE Table A.3 gives target daylight factor (D_T) and minimum target daylight factor (D_{TM}) corresponding to target illuminance level and minimum target illuminance, respectively, for the CEN capital cities.					

Table 2 Recommended daily sunlight. (NEN-EN 17037+A1, 2021)

Level of recommendation for exposure to sunlight	Sunlight exposure
Minimum	**1,5 h**
Medium	**3,0 h**
High	**4,0 h**

3.1 Evidence- based design

The field of evidence-based design (EBD) made advances in the last 40 years, by using the obtained scientific knowledge and methods as a tool for guiding the new healthcare facility designs. Important elements in these guidelines were: improving safety and productivity, reducing waste, enhancing sustainability, reducing stress levels for the users. EBD provides data on what works in real scenarios and what does not work. It uses the philosophy of empiricism in the built environment, which seems to be the right choice for creating buildings what will be used for years and have high demands. (Ulrich, Berry, Quan, & Parish, 2010)

Evidence- based design (EBD) is based on evidence-based medicine. EBD tries with similar methods to analyse what are the effects of the built environment on people's health. EBD is a very detailed and complex research method, where one factor is isolated from the others and its effects are on people's health and mental well-being are tested. (Herweijer-Gelder, 2016) (Park, Chai, Lee, Moon, & Noh, 2018). Ulrich described EBD as the following: "Evidence-Based Design refers to the process of creating healthcare buildings, informed by the best available evidence, with the goal of improving outcomes and of continuing to monitor the success of designs for subsequent decision-making". (Ulrich, Berry, Quan, & Parish, 2010)

The Centre of Health Design divides EBD into 8 processes: Define evidence-based goals and objectives, Find sources for relevant evidence, Critically interpret relevant evidence, Create and innovate evidence-based design concepts, Develop a hypothesis, Collect baseline performance measures, Monitor implementation of design and construction, Measure post-occupancy performance results. (Taylor, 2022) The 8 design processes can be seen in figure 3.

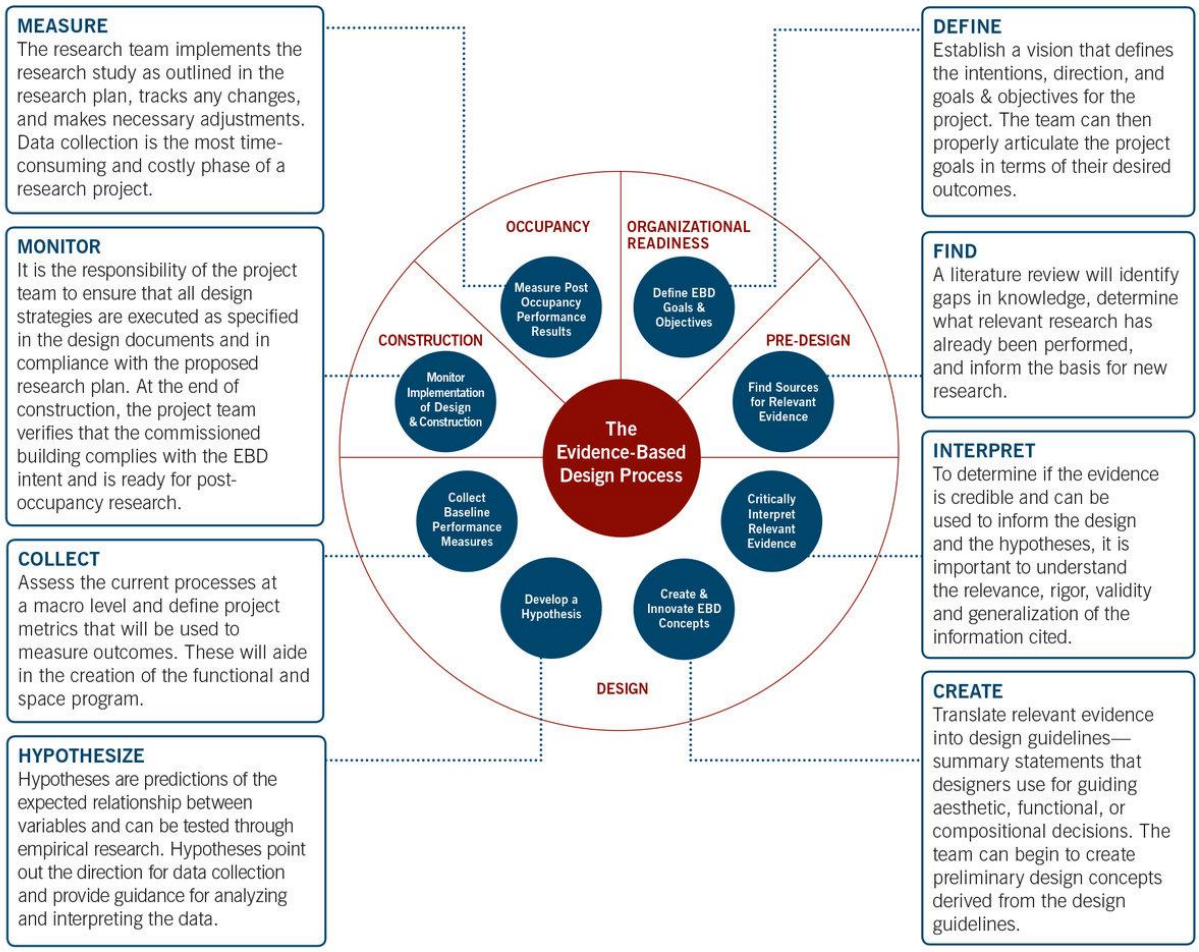


Figure 3 Evidence-based design, 8 design process steps. (Taylor, 2022)

A current aspect in healthcare facilities, is the length of stay (LOS) of hospital patients. The hospital management team focusses on productivity and cost containment in their healthcare systems. To evaluate this factor LOS is often used, LOS a major aspect to measure quality of the patient care, it is also used to assess the allocation of the hospital resources. Because LOS determines the amount of beds needed for each of the hospital wings, it also determines the rotation of the beds. By shortening the LOS per patient an higher productivity in the hospitals can be achieved, it also increases profits, decrease the patient waiting lists and increases patients satisfaction. (Park, Chai, Lee, Moon, & Noh, 2018)

The approach to decrease LOS, is a topic in multiple studies. Walch found by exposing patients with depression to high intensity daylight in the morning reduced the length of stay compared to giving the patients antidepressant by 2-4 weeks. (Walch, et al., 2005) Beachemin researched patient with spinal surgery, he randomly assigned the patients to either a ward with light or a ward were the light was blocked. The patient in ward with light received 46% more light than the other patients, these patient reported to have less pain and distress, they also needed 23% less painkillers. In this study it also revealed that patient with psychiatric disorders, were more sensitive to the difference in the amount of light, it had influence on their LOS. (Beauchemin & Hays, 1998) Choi showed that the resilience of patients was influence by lighting conditions, patients who are placed in brighter daylighted rooms (influenced by the orientation of the room) had a shorter LOS (Choi, Beltran, & Kim, 2012). Joarder showed that intensity levels of daylight illuminance effected the LOS linearly, the patient would reduce its LOS by 7.3 hours per increase of 100 lux daylight. (Joarder, 2013) Ely proved that patient who developed delirium, would have a large increase in their LOS. The patients who were prone to develop delirium were seniors with a critical illness, complication of delirium could be modifiable, when treatment is on time. The patient environment has influence on the development of delirium. (Ely, et al., 2001)

Another current aspect is mortality, Beacuchemin showed that mortality rates of patients are influenced by daylight. Patients in dull environment have a higher mortality than patient in sunny environments. These findings were the same for both sexes. The study was done on patient who had experienced myocardial infarction and were recovering from it. (Beauchemin & Hays, 1998)

3.2 Hospital design

Hospitals are one of the largest multiplex buildings which are built in the Netherlands, these buildings host a lot of necessary staff members. These staff members have almost no experience or knowledge of buildings which creates a discrepancy between them and the architect. Especially with the program of requirement, where EBD could add valuable guidelines in functional programmatic and in the design of the hospital. However often the architect has free rein in the design of the building, whilst the client fails to communicate the information from the people in the field to the architect about the architectural quality of the patient rooms. This all adds to the discrepancy between health experts and the building's design team. To create the optimal healing environment the EBD should be incorporated properly in the guidelines/program of requirements.

The EBD is ever evolving, it reacts to the current changes in the hospitals and try to give proper solutions or lower the influences of the changes on the hospitals. An example of current changes in hospitals: more and more patients have multiple complex ailments which cannot be solved by one expert, these patients need a multidisciplinary team to be able to help them. This leads to more necessary teamwork between the different departments within the hospital, to be able to act accurately and swiftly an accommodation is needed, where staff members of different disciplinary's come together to evaluate the patient together.

While the EBD is ever evolving, the program of requirements of hospitals seems to be left behind. This can be improved by opening a better communication between the design team and the experts in the field. Which can be done by finding an intermediary which can help translate the scientific way of thinking to the more visual one. (Herweijer-Gelder, 2016)

3.3 Daylight

In hospitals, as in other contexts, rooms which are lit by natural daylight help keeping the patients on their normal 24-hour sleep-wake cycle, thus preventing the disruption of patient's circadian rhythm. Many molecular biochemical processes and their paring characteristic of human behavior are driven by the circadian rhythm. In the last 7 years evidence has become publicly available, which proves a connection between abundant clinical diseases and disrupted circadian rhythms. Clinical evidence is brought up which shows that if circadian rhythms are disrupted in humans, development of metabolic syndrome and obesity, hypertension, cardiac arrhythmias and abnormal sleep cycles can occur. Although the effect of long-term disruption of the circadian rhythm is well described, the short-term effects are less clear, which could have influence on patients going under anesthesia and having surgery.

Brainard et al. discovered that the molecular changes that occur in the circadian rhythm are affected by exposure to daylight. Many important regulators are representing this link between the circadian rhythm and daylight exposure, examples are oscillating per2 and melatonin expression. The per2 (period circadian period) is the gene which is important for the modulation of the circadian rhythm. Melatonin is a hormone which is produced in the back part of the brain (pineal gland). The pineal gland produces melatonin in responds to darkness (absence of light) and helps in the timing of the circadian rhythm. Due to the discovery of the link between circadian rhythm and daylight exposure, daylight therapy could be described as a potential noninvasive and low risk therapy for critical illness prevention and treatment. (Brainard, Gobel, Scott, Koeppen, & Eckle, 2015) (Wang, 2015) (Beute & de Kort, 2018) (Simons, et al., 2014)

Daylight influences people's health and daily tasks through four mechanisms in the human body: it influences the possibility to execute visual tasks, it controls the day and night cycle of the human body, it influences the state of mind and normal perception, it creates a critical chemical reaction on the human body which is needed (such as creating natural vitamin D). (Herweijer-Gelder, 2016)

A lot of processes in the human body which involve hormones are influenced strongly by the day and night cycle. For example regulating body temperature, production of stress hormone (cortisol) and the production of natural vitamin D. When a human body exposed to outdoor direct sunlight vitamin D is created, this hormone plays an important role in regulating the metabolism. The produced Cortisol and melatonin have influence on people health, their moods, well-being and performances. Light also influences health outcomes, it reduces length of stay, it reduces pain perception. The reduction of pain perception can lead to reduction of pain medicine for patients. (Herweijer-Gelder, 2016)

Walch conducted a study on patients who were recovering from an elective spinal surgery, he randomly divided the patient into the 2 sides of the hospital unit, the dim and sunny side. The patient on the sunny side of the hospital unit received 46% more daylight than patient on the dim side, they also required 22% less analgesic medication during the LOS. The use of analgesic medication(opioid) can lead to side effects. The development of side effects is closely related to the amount of medication taken, so by reducing the amount needed the chance of developing side effects can be decreased. The patient from the sunny side also reported a greater decrease in perceived stress at the end of their LOS. (Walch, et al., 2005)

The research on the benefits of daylight and views for patients have shaped modern healthcare design practices and guidelines, and all patient rooms are required to have windows. However, these large windows do not always have the ability to effectively control the amount of solar penetration to avoid visual and thermal discomfort.

Sherif conducted research on blinds, where he looked at the level visual comfort and thermal discomfort compared to the daylighting performance and sky view of the window. The study shows that fixed blinds with horizontal slats are quantitatively justified, they provide a decent daylight performance and sky view. (Sherif, Sabry, Wagdy, Marshaly, & Arafa, 2016)

Choi did a study on the effect of daylight on the LOS of patients. From the study could be derived that discomfort from glare and excessive daylighting in the sunny rooms could be solved by (partially) closing the blinds, the study also suggested that shading devices which can be controlled by the patient could have a positive effect on their physiological and psychological conditions.

Because being able to react to swiftly changing sky conditions by blocking disturbing excessive daylight could increase their level of satisfaction. (Choi, Beltran, & Kim, 2012)

A few other studies have addressed the use of blinds and window shading systems to control daylight, glare, and access to views in patient rooms to improve comfort among patients and staff. The studies showed that the ability to control overall light levels in a room, by dimming daylight and having additional electrical lighting available were prominent for patient and the staff. Also became evident that more attention should be paid to the way a window shades and the placement of outdoor light sources and the ability to block them. So, it was suggested to further optimize the lighting framework in patient rooms. (McCunn, Safranek, Wilkerson, & Davis, 2021) (Quan & Joseph, 2017)

Koneczny showed in a study that the patient room on the first floor should be able to block the view in a certain way to provide privacy for the patient when necessary. This can be done by frosted plastic films, to let sunlight and block the view partially from the bottom side of the window. This solution would give the patient the option to leave the blinds open during the daytime. (Koneczny, 2009)

3.4 Window view

The windows offer a gateway to the world outside, patients can mentally escape the busy or unpleasant room they are confined in. This positive detracting stimulus can reduce the activity in the sympathetic nervous system which leads to reduction of pain perception. Also, it reduces blood pressure, pulse frequency and muscle tension. (Herweijer-Gelder, 2016)

A few studies proved that daylight and access to window view have improvements in symptoms and health outcome for patients.

Gharaveis researched showed that visual environment can have great influence on patient with a critical illness. Patients with cancer would benefit from healthcare design which would enhance their hospital experience. The environmental design around the patient room was seen as a critical factor for success of healthcare systems regarding cancer care. Providing patients with access to diverse facilities, nature and healing landscape would improve their satisfaction level and quality of life. Also, spaces with controlled noise and natural lighting, has benefits for the patient well-being. (Gharaveis & Kazem-Zadeh, 2018)

Critically ill patients are more likely to develop delirium while hospitalized. Recent studies can be derived that patients in rooms with window or without window did not have influence on the incidence of delirium. However, patients in rooms with window would have a less severe agitation episode intervened with neuroleptics and hallucinations. Patients in rooms with windows and daylight also have less severe episodes intervened with antipsychotics. Which suggest a beneficial role of windows and daylight exposure to prevent hyperactive delirium. (Zaal, et al., 2013) (Smonig, et al., 2019)

The window composition can be divided into layers, and these layers can be analysed and a distribution list could be made with the present elements in each view lines. Far away elements can be present in window views as well, which give it great benefit in a window composition. From previous research, it can be concluded that artificial elements (for example streets, buildings and sidewalks) have a negative effect on people’s preferences, however these elements are in most cases not avoidable. But these elements can be influence in a window view by their respective distance, distribution and aesthetic value. (Lin, Le, & Chan, 2022)

Factors which determine the overall quality of a view are complex. Therefore, it is important for designers to consider the window content, access, and clarity of window views within the context of the project considering the cultural, demographic, social, and physical aspects. It is difficult to provide a high-quality view if any one of these components is neglected, so consideration of all factors is important. (Ko, 2022)

The window view has an additional benefit, which is the effect of visual distractions. The view outside could grab patients' attention and give them diversions throughout the day, these diversions could awaken other senses, they can calm the mind and reduce feeling of stress. The attention level should be in balance, too many stimuli could have an increase of stress as a result. While having not enough stimuli could lead to people feeling bored or even depressed.

The diversions could even lead to reduction of pain. This theory assumes that during the day patient's attention is largely focus on their injury or illness. When the mind gets distracted by a positive stimulus, less attention will be directed to the pain. This leads to a decrease of pain perception. (Herweijer-Gelder, 2016)

The stress-reducing effects of views through windows in healthcare settings have been emphasized in the theory of supportive design, which revolves on the healthcare facility's role in fostering coping with stress, an obstacle to healing. (Ulrich, 1991)

Providing patients an outside view, preferably overlooking a garden, courtyard, or other natural settings may help relieving anxiety and stress, improve care, enhance patients' comfort, and improve patient orientation. In situations where a patient's bed must face the interior of the room to be able to be monitored by the staff, an adjustable mirror could be mounted on the wall or ceiling to provide the patient with a reflection of the outside view. (Thompson, et al., 2012)

Another stimulation for patient would be the connection to nature. Contact between people and nature in the built environment is called positive environmental impact, or "biophilic" design. Biophilic design includes two basic dimensions: organic (or naturalistic) design and vernacular (or place-based) design. Vernacular design refers to buildings and landscapes that foster an attachment to place by connecting culture, history, and ecology within a geographic context. These 2 design techniques could be used for healthcare design to take biophilia of patient into consideration. (Kellert & Wilson, 2003)

The human feeling of needing to connect with nature is called biophilia. Biophilia makes psychological and physical rejuvenation possible and it could increase cognitive performances as well. Research proved that an adequate connection of nature could result in reduction of stress, disappearing of negative emotions and increase in positive emotions, improvement in dealing with pain which leads to decrease in pain medication intake and increase in patients' and visitors' well-being. (Herweijer-Gelder, 2016)

4. Problem statement

The importance of the research field, physical environment and the effects on people's well-being, is highlighted since the report of Ulrich 1978. However, since this topic has an influence on a large amount of people, the difference between people gives the topic its multifaceted aspect. Which means many different angles on this topic have not been research yet or are still lacking research data.

Notably the people who are sick and/or injured (hospital patients), are confined inside hospital patient rooms while they recuperate. The effect of relevant factors of view to the outside and the daylight parameters on the length of stay (i.e., on patients' wellbeing and recovery), is still lacking in research. This led to the research question of this graduation project paper: **Which relevant factors related to the view to the outside and/or to daylight parameters influence the visual perception of people?**

To be able to fully answer the research question, four sub-questions were defined. These were aimed to: isolate the effect of building orientation on the visual perception, to divide and research the view and daylight parameters in two main categories and to see if parameters from these two categories influence each other. The four sub-questions were the following:

1) Is there a difference in pleasantness and or interest between rooms with different orientations?
2) Do daylight parameters influence the pleasantness and or interest rating?
3) Do view parameters influence the pleasantness and or interest rating?
4) Is there an interaction between view and daylight parameters influencing pleasantness and or interest rating?

To start answering these sub-questions the relevant view factors and daylight parameters had to be determined. For determining the factors and parameters, the available research data played a large role. For the view factors the available dataset contained, 1188 fish eye photos and the 3D model of the Erasmus MC and the surrounding buildings. With the available data, research papers on the topic of outside view evaluation were researched to be able to determine the relevant view factors . (Matusiak & Klöckner, 2015) (Lin, Le, & Chan, 2022)

These factors with the measurement unit and reasoning are given in table 3.

Table 3 Outside view factors.

Number	Factor	Unit	Reasoning
1	Building ratio	%	To evaluate the influence of the amount of building presence in sight. In most city landscapes buildings would play the largest part in outside views.
2	Sky ratio	%	To evaluate the influence of the amount of sky presence in sight. View to the sky gives people valuable information on the condition outside.
3	Greenery ratio	%	To evaluate the influence of the amount of greenery presence in sight. Connection to nature from the inside is important to people on a psychology level.
4	Street water ratio	%	To evaluate the influence of the amount of street/water presence in sight. The sight of water and activity on the street leads to a positive distraction and connection to the outside world.
5	Distance to nearest surrounding building	Meters	It influences the window scape drastically, it can block the sight to the city/surrounding area, it also can give a connection to people on the outside.
6	Composition of the view is orientated in horizontal layers	Yes/no	It influences the easiness the view can be taken in.
7	Far away element	Yes/no	The presence of a recognizable far away element has positive distraction value in the sight. It also has added to the pleasantness of the view as a whole.
8	Human presence	Yes/no	Helps to connect the inside with the outside world and to distract the patient.
9	layers	Amount	Has influence on the pleasantness of the view.
10	Layer sky, as described and evaluated in the NEN-EN 17037	Yes/no	Contains information of the outside, connect the patient to circadian rhythm.
11	Layer building, as described and evaluated in the NEN-EN 17037	Yes/no	It influence the view.
12	Layer ground, as described and evaluated in the NEN-EN 17037	Yes/no	It contains valuable information and connect patient to outside life.

For the daylight parameters the available data were 3D model of the Erasmus MC. Luminance mapping of the fish eye photos and the illuminance values of the weather data files in combination with the fish eye photo research. The parameters with the corresponding units which could be retrieved from the available data are given in table 4.

Table 4 Relevant daylight parameters.

Number	Parameter	Unit
1	Average luminance	Cd/m2
2	Vertical Illuminance	Lux
3	Horizontal Illuminance	lux
4	Illuminance ratio	
5	Daily duration sunlight	Hours/per day

To be able to get a better understanding on the quality of the outside view, a survey was made to collect data on the pleasantness of the view. The survey was distributed through a channel where a wider variety people could participate. For the survey 8 videos of different outside views in patient rooms were shown in videos made from 360-degree photos. The participants are asked to rate the view on the scale of 1-10 on pleasantness and interest, 1 is unpleasant/uninteresting and 10 is pleasant/interesting. In the chapter 5.2, the survey is explained in more detail. The views factors in each individual picture are then evaluated and compared to the pleasantness and interest rating.

After analyzing if the view factors and daylight parameters have a correlation with the pleasantness and interest rating, two sub research questions were defined. These questions are the following:

1) Is there a correlation between the variables and the subjective pleasantness and interest ratings of window view?
2) Are the people's ratings on the view to the outside from hospital patient rooms, related to the standardized parameters that qualify view?

From the papers which were researched it could be derived that the greenery in field of view is appreciated, a certain amount of luminance level is beneficial and needed for certain functions and executing tasks, amount of daylight hours influences the circadian rhythm and have influence on people mental health. (Benedetti, Colombo, Barbini, Campori, & Smeraldi, 2001) (Beute & de Kort, 2018) (Brainard, Gobel, Scott, Koeppen, & Eckle, 2015) (Kellert, 2006) (Lin, Le, & Chan, 2022)

Which led to the following four hypotheses,

1) Windows in a hospital patient room with a higher percentage of greenery in the window view have a more positive effect on people visual perception.
2) Windows in a hospital patient room with higher daylight luminance/ illuminance levels have a more positive effect on people's visual perception.
3) Hospital patient rooms with a higher amount of daylight hours have a more positive effect on people's visual perception.
4) The selected view factors can predict people's pleasantness ratings of the hospital window views.

5. Methodology

5.1 Data sets

To be able to test the hypotheses, pictures of window views from different hospital patient room had to be taken. Each chosen hospital room with its respective view, were photographed in a series of 9 pictures with the use of a LMK luminance camera and a fisheye lens. These pictures series were taken so luminance maps from the hospital patient rooms could be retrieved. The picture below shows an example of one of the pictures series.

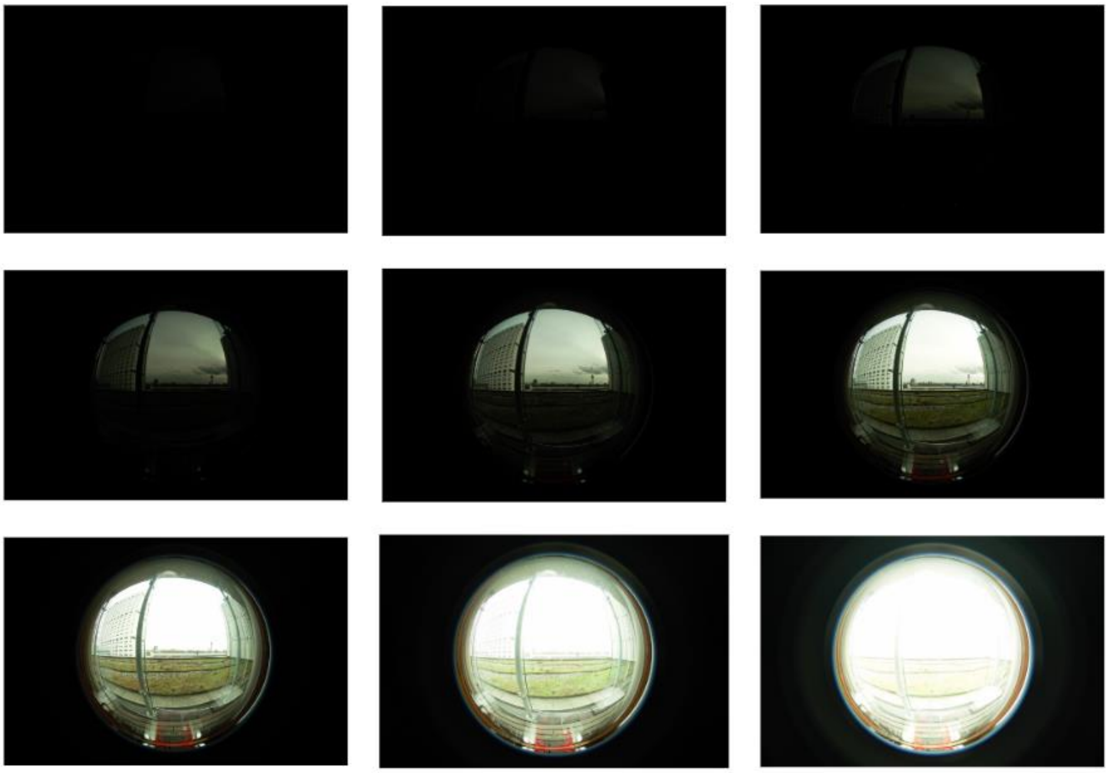


Figure 4 Photo series taken with a LMK luminance camera and a fisheye lens.

From these photos series a luminance map could be retrieved and a view compositions could be made. The figure 5 below shows the luminance map of the photo series of figure 4.
Figure 6 shows the chosen technique to analyze the window view composition. Then each view line is divided into several view composition elements (for example greenery, buildings, street and sky), and the total view distribution is calculated. The view elements of the view lines are traced by using photoshop.

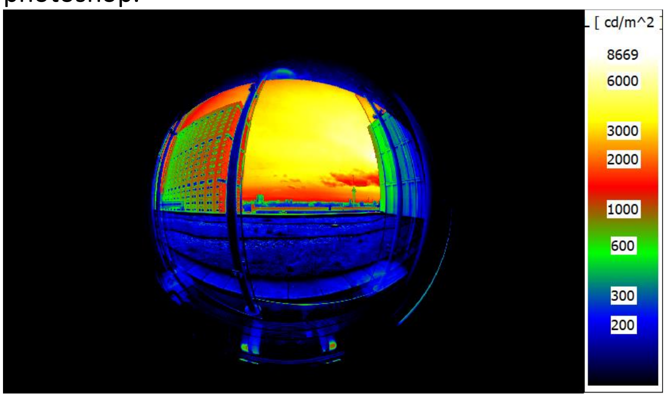


Figure 5 Luminance mapping.

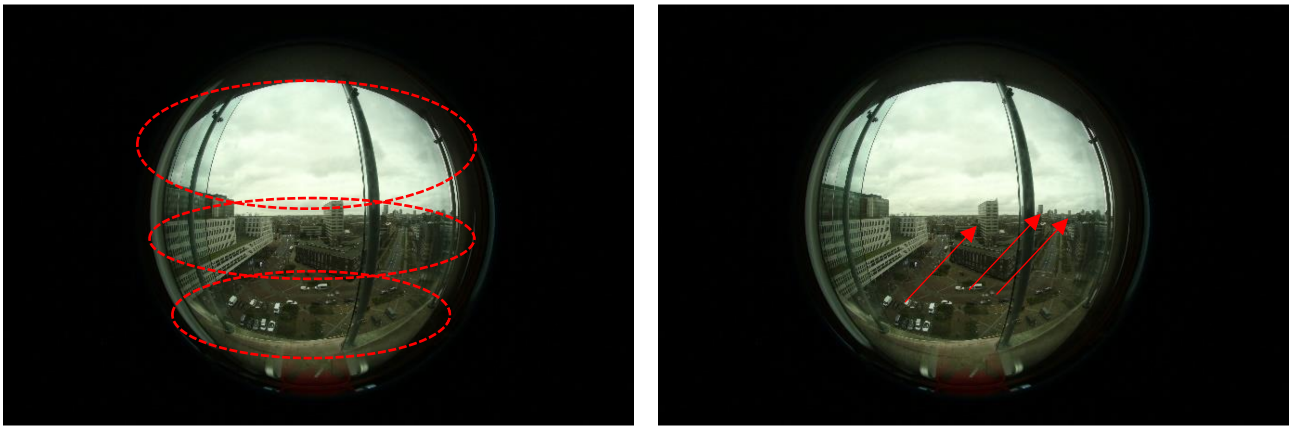


Figure 6 Window view analyses.

The data available for the project consist of fish eye photos, luminance mapping configured from the photo series, simulation of the hospital and the surrounding area, the HDR pictures configured from the fish eye photo series.

From each of these datasets a variety of view and daylight factors were retrieved. For the photo analyses the following factors were retrieved: building ratio, greenery ratio, sky ratio, composition horizontal layers, amount of layers in scenery and which layer(s) is present from the 3 possible layers(sky, building, ground).

The sky greenery and building ratio were retrieved by tracing the element of each category. With the known amount of total area of the picture, each ratio could be calculated by $\frac{area\ category}{total\ picture\ area} * 100$. Figure 7 shows one of the hospital window views with its corresponding traced image.

The presence of horizontal layers, number of layers and which category of layer is present, is analyzed by looking at each individual window view. When the scenery of the image was predominantly developed in a horizontal direction it was given evaluated as such. The number of layers according to the NEN is ranging from 1 to 3. These 3 layers were categorized as ground, building and sky layer (NEN-EN 17037+A1, 2021). An example of an analyzed window view can be seen in figure 7.

Figure 7 Hospital window view with its corresponding traced image.

For luminance mapping, the photo series of 9 were converted by using the software program LMK softlab. From the retrieved luminance mapping a few factors could be retrieved, the amount and location of different luminance zones in the view, also an average luminance value could be calculated in the program. The latter will be used as input value in the data set. Figure 8 shows one of the configured luminance mapping.

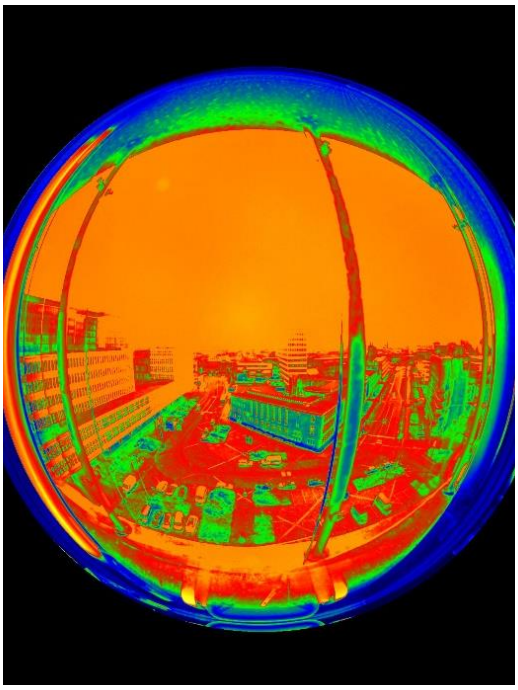


Figure 8 Example luminance mapping.

From the 3D simulation of the hospital and the surrounding areas, the distance from each individual room to the closest building could be retrieved, a daylight simulation will be done for each building site.

The distance is measured from the room perpendicular to the closest building.

The daylight simulations are executed in Rhino, while following the requirements from the NEN, mainly concerning the placement of the measuring the daylight factor inside the room.

The vertical illuminance data was retrieved from the measurements data of the fish eye photo. The horizontal illuminance data was calculated by multiplying the irradiance by the luminous efficiency factor of 120. The irradiance data was obtained from the weather data files the day the fish eye photo were taken (Isabella, 2023). From the vertical and horizontal illuminance values a ratio could be found for each room.

5.2 Survey

The survey was created to get people to rate the window views of the Erasmus MC from 1 to 10on pleasantness and interest, to see if the selected factors in the research play an important role in the rating of the views. For the first survey an audience was selected from experts who were present at the ARCH22 conference in delft (ARCH22 – the 5th Architecture Research Care and Health conference, 2022). At this conference pamphlets were distributed with a QR code on it so people could fill it in when they had time. The survey consisted of 4 blocks of 5 images, these images in each block were photo of the hospital window view of different sides. The images were taken from the HDR converted photos.

The participation rate of the survey was not as expected, only 3 people filled in the survey fully. From this fact we concluded that the pictures couldn't hold the attention from the participant, they were gloomy and repetitive.

After re-evaluating the data and available pictures, it was decided to rework the second survey. To a 1 block of 8 videos which show each a different view to the outside of the hospital. The views were chosen to illustrate each of the building orientations and there corresponding views. The 8 videos were taken from 360 degree pictures taken in the hospital patient rooms.

The survey was filled in by students, people visiting the schools and people contacted online. When enough people participated in the survey, the analyses was made using the Qualtrics program, this analyses was then compared to factors used in the data analyses and which are present in the image.

To analyse the survey components, correlation was evaluated between the 2 components and the variable. These correlations are shown in table 6.

Table 5 Correlation grouping between components of the survey.

	Amount of layers	rating	rating
	% green	Pleasantness	Interest
	% sky	Pleasantness	Interest
	% buildings	Pleasantness	Interest
	%street water	Pleasantness	Interest
	Amount of layers	Pleasantness	Interest
	Distance	Pleasantness	Interest
	Human presence	Pleasantness	Interest
	Illuminance ratio	Pleasantness	Interest
	Daylight factor	Pleasantness	Interest
	Sunlight hours	Pleasantness	Interest

6. Results

The data analysis contains 94 hospital rooms, 83 of those rooms on the 8th floor and 11 on the 9th floor. From the 83 rooms on the 8th floor, one room per view direction was chosen to be implemented in the survey. The analyzed patients' rooms were illustrated in the figures below in grey for the 8th and 9th floor, the rooms colored in red were used for the survey.

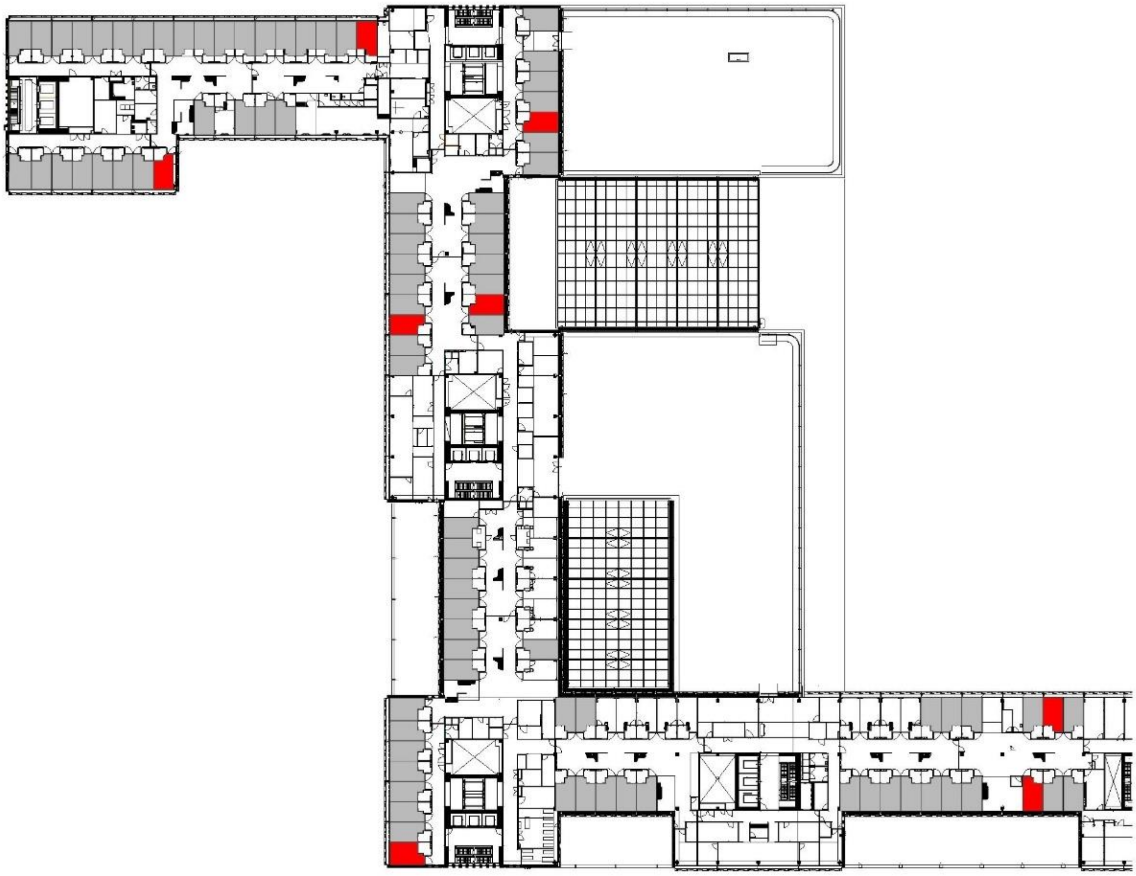


Figure 9 Analyzed patients' rooms on floor 8, with the selected survey rooms in red.

The 8 rooms which were used in the survey were chosen due to their view direction and availability during the photographing process. In the pictures below the 8 views are shown with their respective view directions.

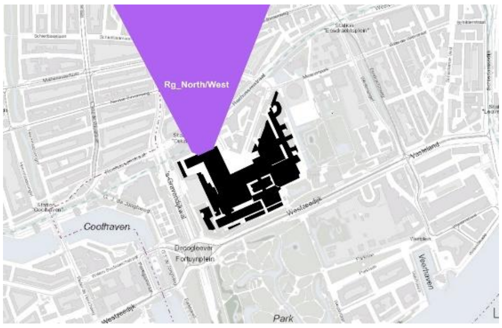


Figure 10 View direction 1, room RG801.

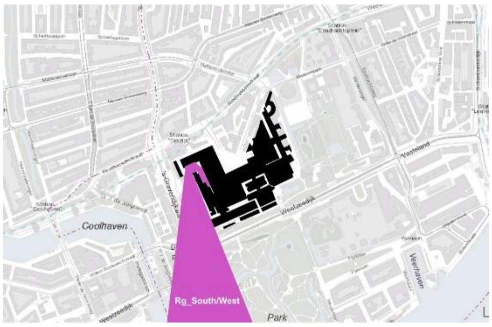


Figure 11 View direction 2, room Rg822.

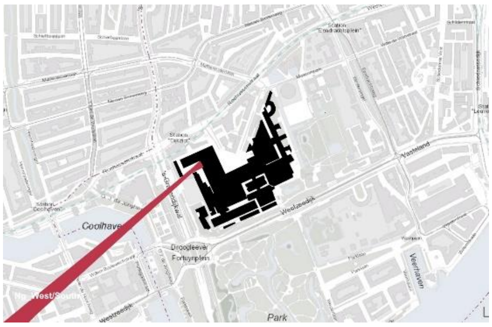


Figure 12 View direction 3, room Ng805.

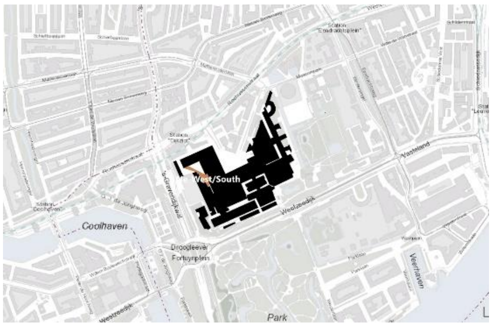


Figure 13 View direction 4, Ne801.

Figure 14 View direction 5, room Nc834.

Figure 15 View direction 6, room Nc831.

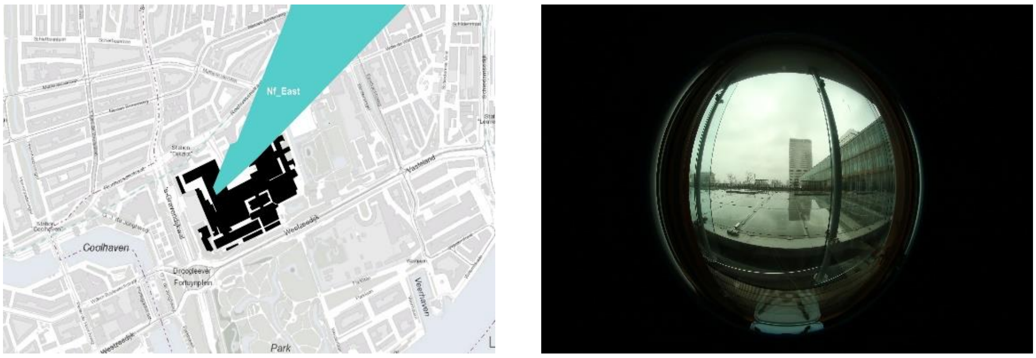


Figure 16 View direction 7, room Ng808.

Figure 17 View direction 8, Ng822.

6.1 View factors data set

6.1.1 Layers

Concerning the NEN-EN17037, the window view was divided into 3 layers: sky, landscape, and ground layer. In the figures below the division of the views in layers are first shown for all the researched rooms, then the number of layers is also shown for each of the hospital building view directions. Most of the view directions only had a set number of layers, except for Nc and Nf which had 2 types of layers composition in their view. Which indicates that for each view direction, the view composition per room was similar. However, the view composition could vary per floor for each view direction.

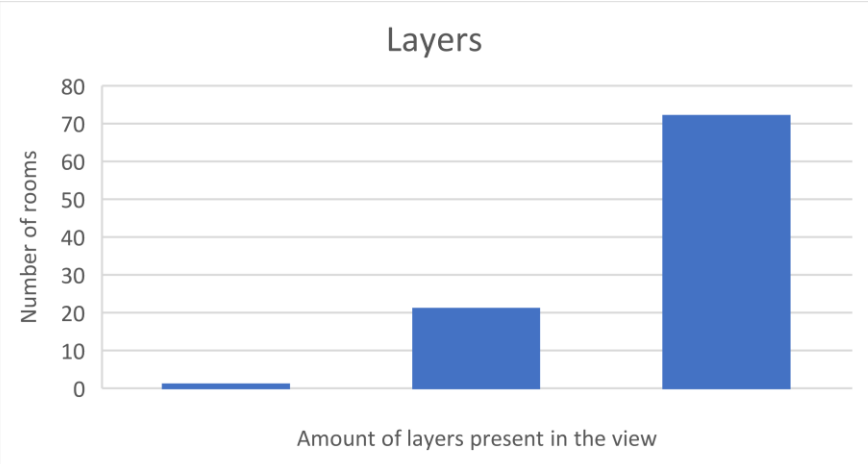


Figure 18 Overview number of layers for all the researched rooms.

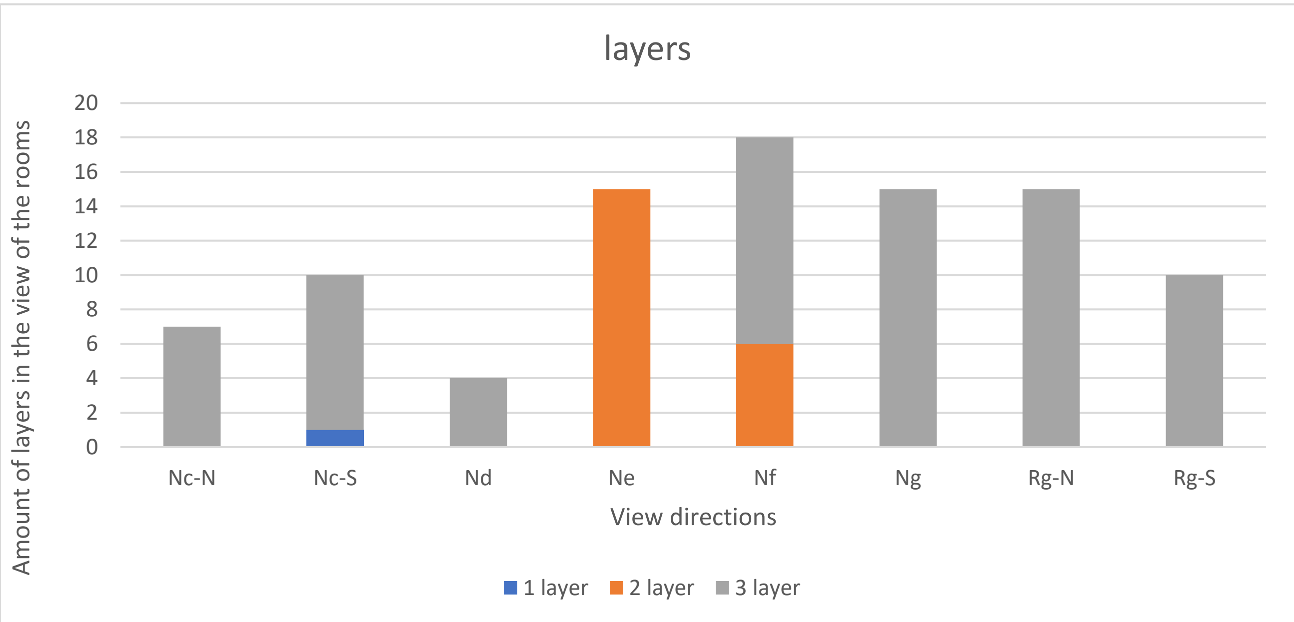


Figure 19 Layers for all view directions.

6.1.2 Sky ratio

As explained in section 5, the views were analyzed on the number of different factors. One of the factors was the sky ratio, in the figures below the sky ratio for the total amount of rooms and for each of the view directions is shown. When compared the majority of the directions were averaging between 17 and 20 %, the outliers were Nc north, Rg north and Ne. For Nc north and Rg north the average was 9 to 6 % higher and for Ne the average was 9 to 6 % lower and with an outliner of 6 % sky coverage. Another notable fact is the one outliner point for the Nc south direction where the value was around 2 %, for this room the view was partially obstructed by a safety net.

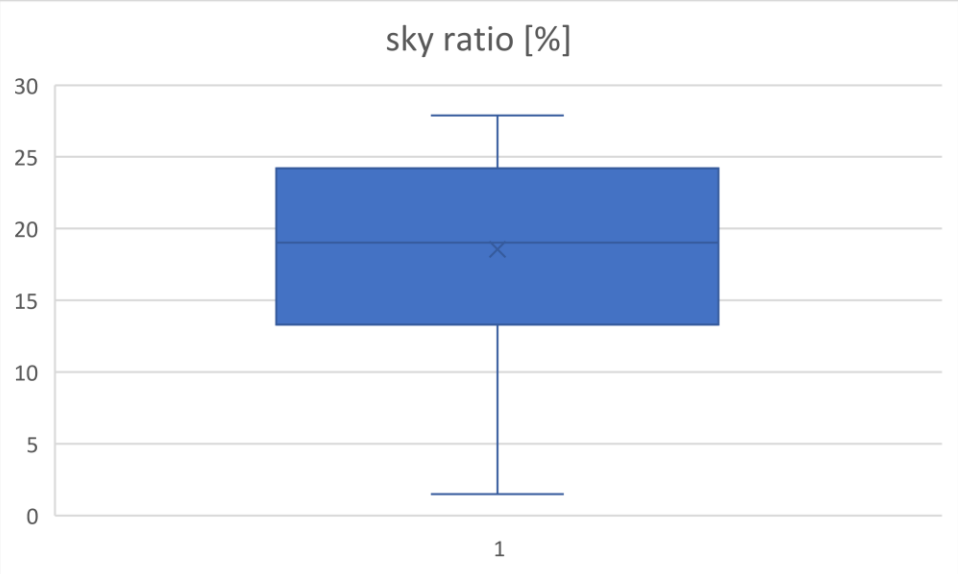


Figure 20 Sky ratio for all research rooms.

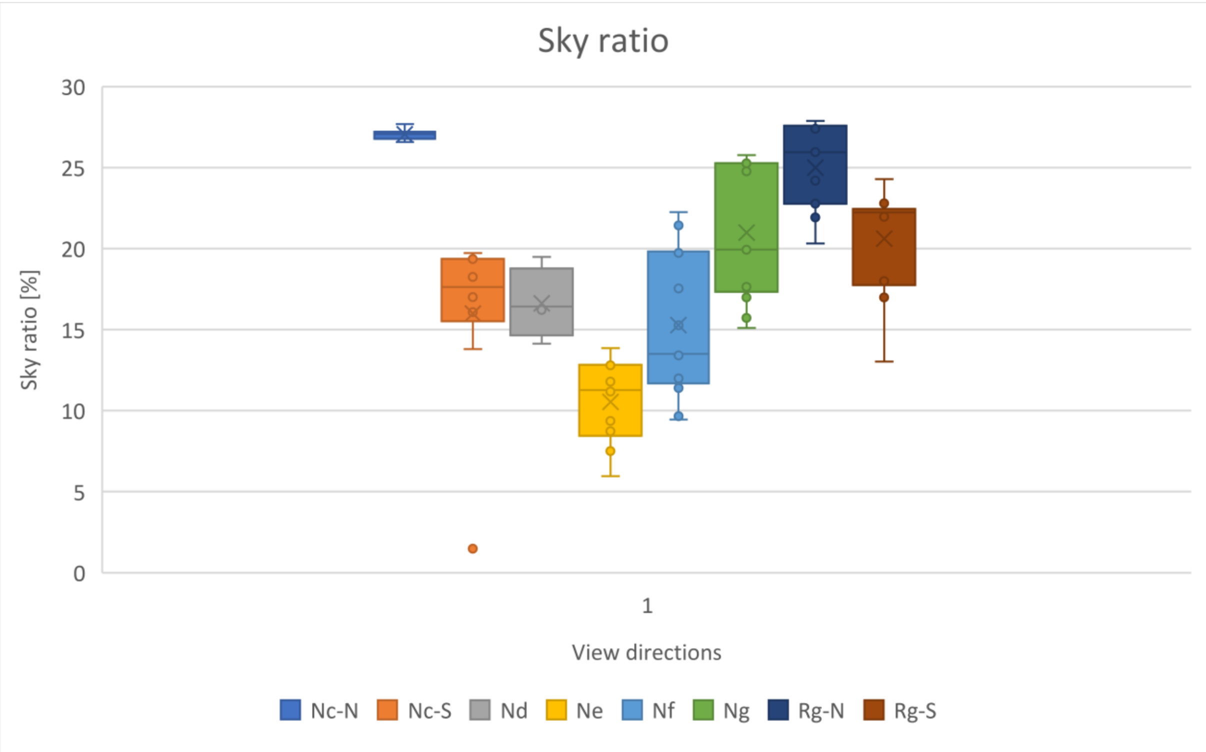


Figure 21 Sky ratio for all the directions.

6.1.3 Building ratio

The building ratio for all the researched rooms are shown in the figure below as well as the building ratio for each of the view directions. The average percentage of the building is around 18 to 20, for most view directions the average was around 15 to 21. Except for the view direction Ne which was dominated by the building view and had an average of 44 %. For view direction Nf could be noted that it had high outliners of 35 %, which indicates a larger variation of views for the compatible rooms. Another notable component was the two-point outliners of the Rg south direction, the outliners were above and below the average. Lastly the Ng direction had an average of 12 %, but a large number of rooms have a 6% building coverage.

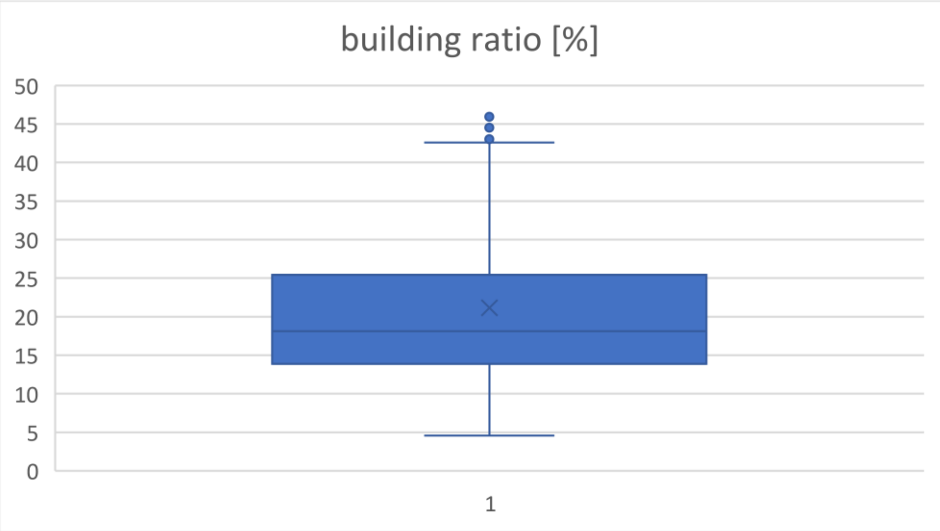


Figure 22 Building ratio for all the researched rooms.

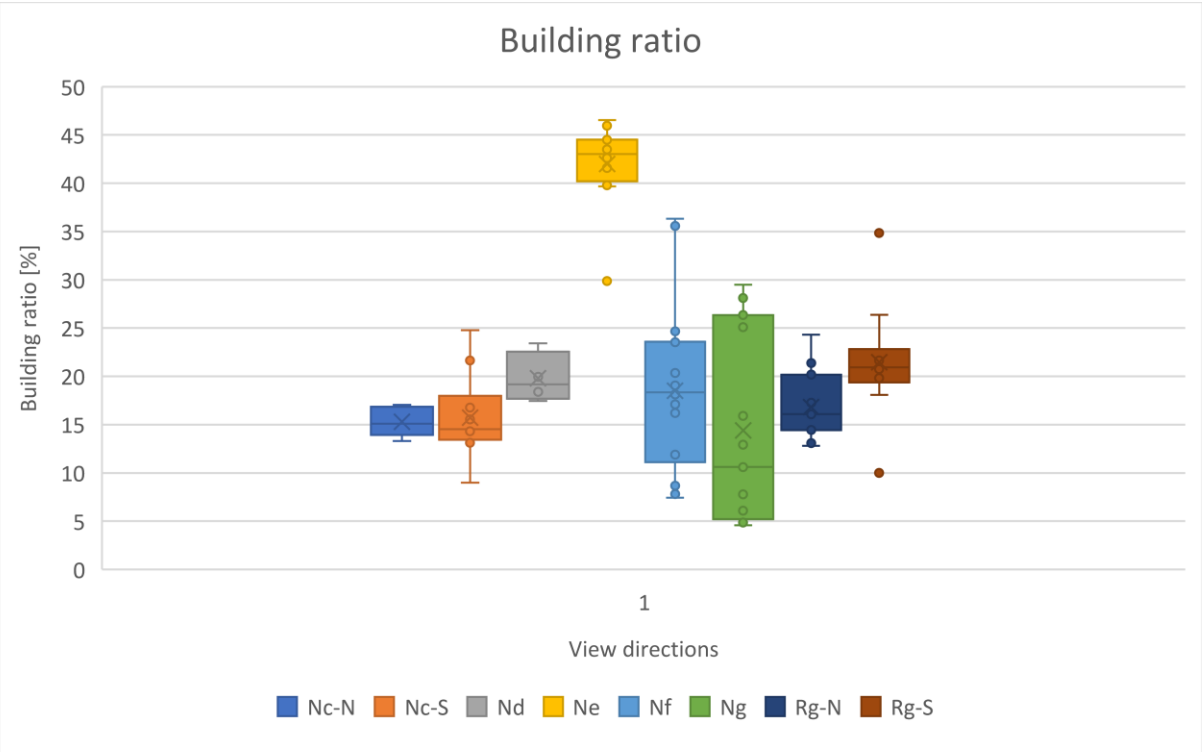


Figure 23 Building ratio for all directions.

6.1.4 Greenery ratio

The greenery ratio for all the researched rooms is shown in the figure below as well as the building ratio for each of the view directions. The average greenery was around 2-3 %, however it had large number of outliners to 15% as well as point outliners of 19 %. For the rooms which were located near the roof gardens the average greenery percentages were similar to each other and higher than the directions not located near the roof gardens. The direction near central roof garden were Nf ,Ng and Nd. The rooms to other roof gardens was Nc south. For the rooms in view direction Ne and Rg south the greenery was nearly 0 5 due to the fact that the views were primarily dominated by buildings.

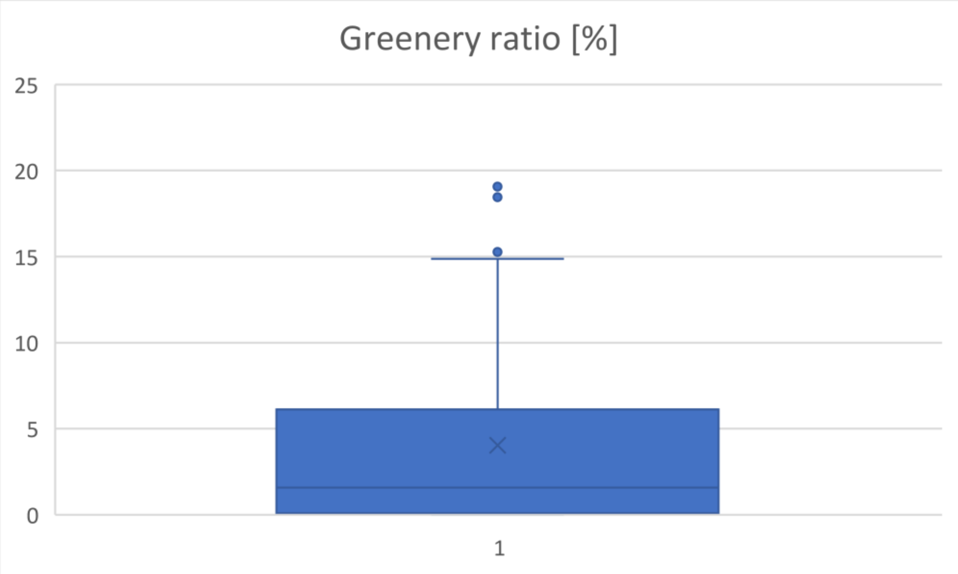


Figure 24 Greenery sky ratio for all the researched rooms.

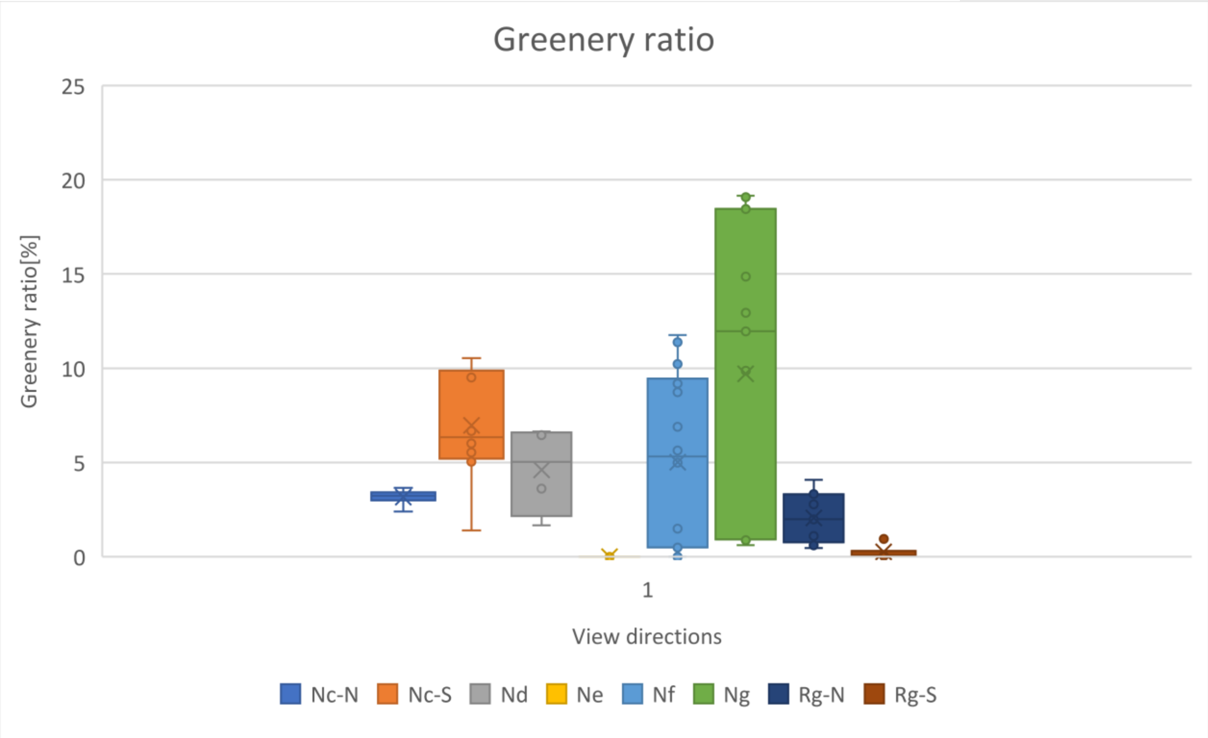


Figure 25 Greenery ratio for all directions.

6.1.5 Street/water ratio

The street/water ratio for all the researched rooms are shown in the figure below as well as the building ratio for each of the view directions. The percentages of street/water in the view were low compared to the other factors which were illustrated before. In even 4 of the 8-view direction there was nearly 0% present, this was the case for Nc south, Nd, Ne and Nf. The largest averages were in the view directions Nc north and Ng, which show the streets to the main entrance to the hospital.

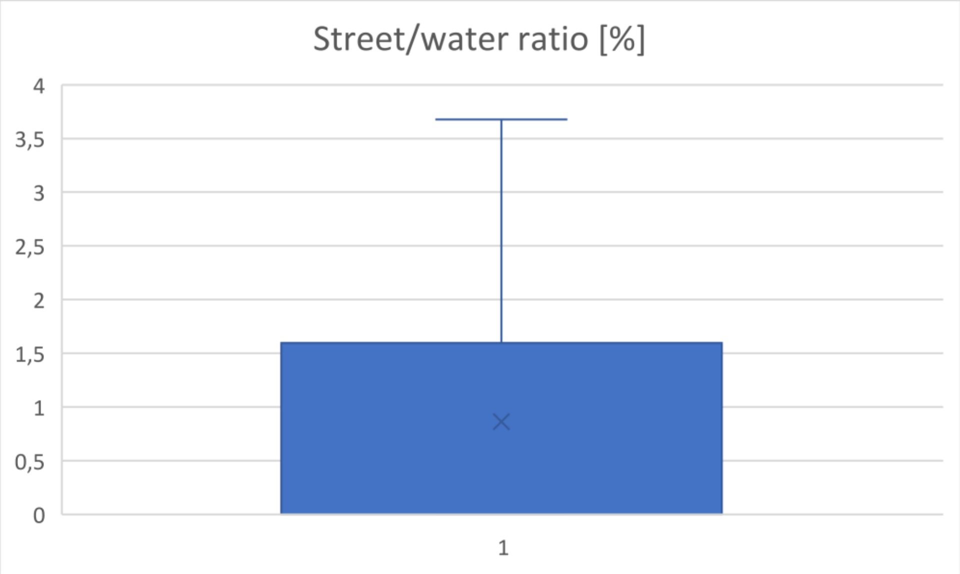


Figure 26 Street/water ratio for all the researched rooms.

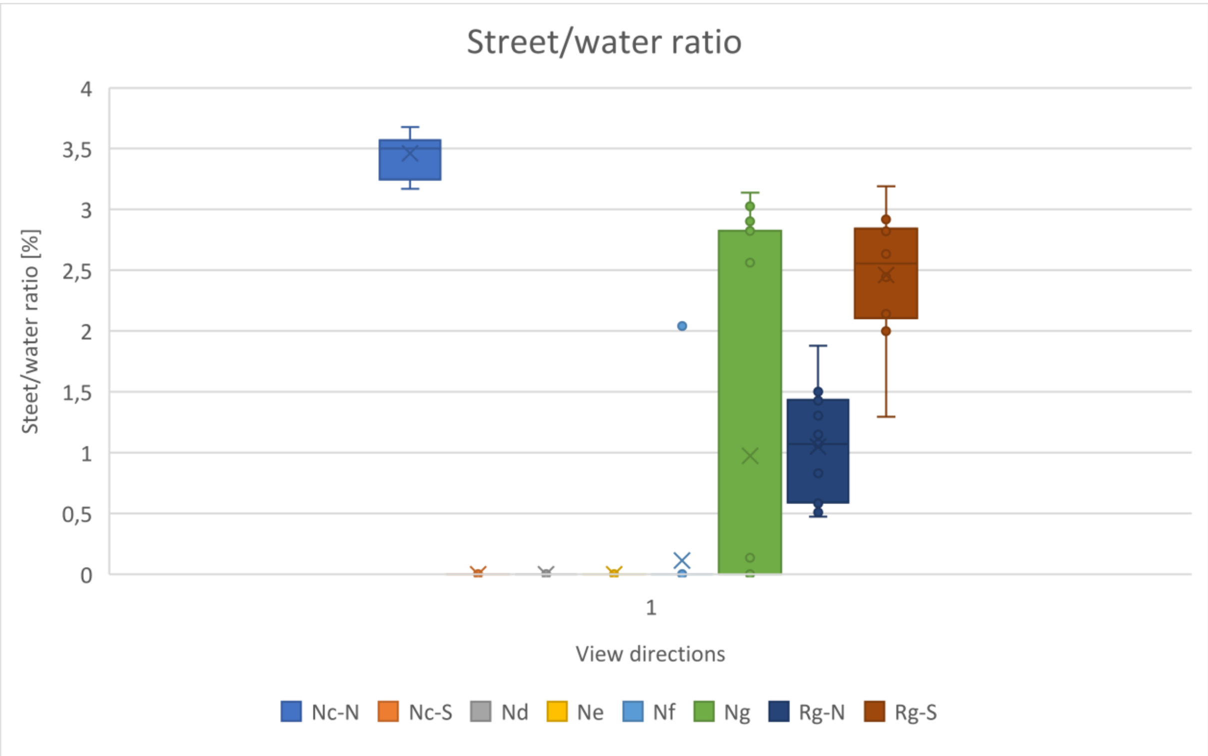


Figure 27 Street/water ratio for all direction.

6.1.6 Distance

The distance between the hospital windows and the closest building is shown in figure 63. In the overall distance graph, the average were around 55-56 meters with large outliners of 125 meters and 24 meters. The view directions Nc south, Ne, Rg north and Rg south have their values around average without large outliners, which show that the view direction was located across a building or multiple buildings at the same distance. There for the presence of the building in the view was similar. However, the view directions Nd and Nf have large outliners which indicate the presence of the building across the window view differs a lot.

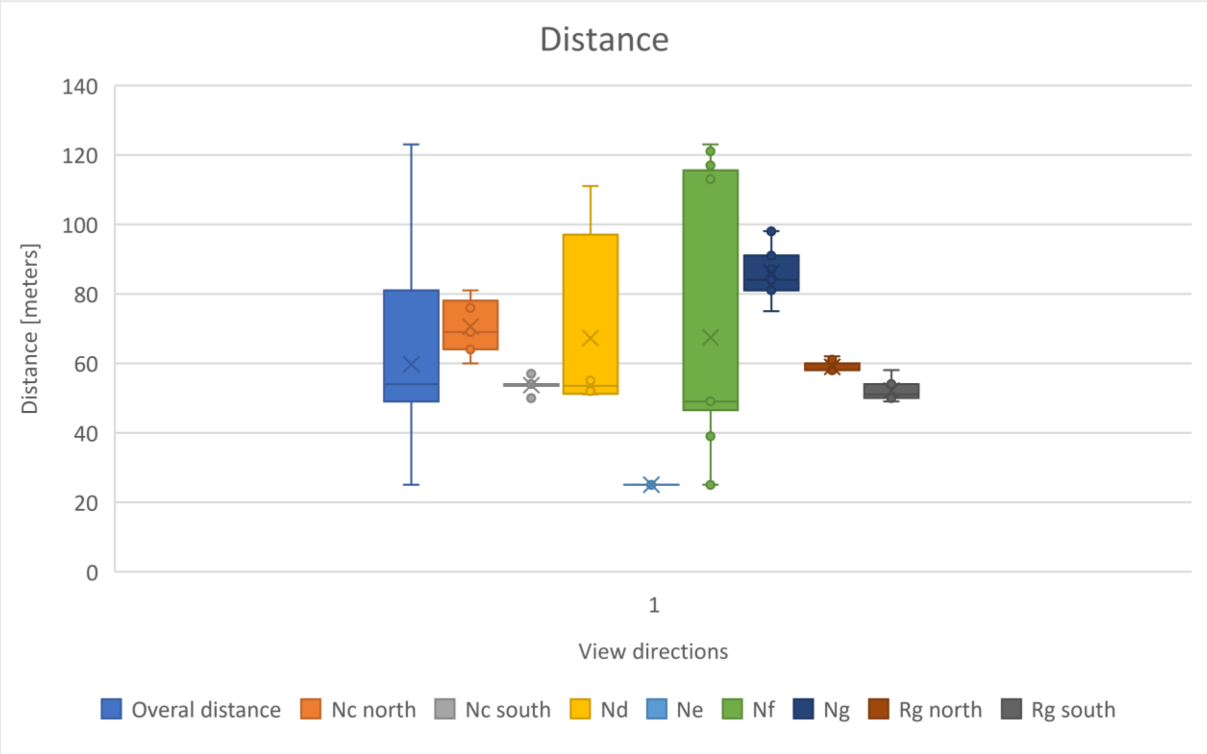


Figure 28 Distance between the room and the closest building.

6.2 Daylight parameter data set.

6.2.1 Illuminance

The illuminance ratio was calculated by dividing the indoor vertical illuminance by the outdoor horizontal illuminance. The vertical illuminance was measured with an illuminance meter before and after taking the fisheye photos of the view from the patient window view. The horizontal illuminance was calculated by multiplying the radiance by the luminance efficiency constant. Where the radiance value was retrieved from a weather data station (Isabella, 2023), which measures the radiance every hour of the day at a weather station near the Erasmus MC.

The radiation was also simulated in the 3D Rhino Model with the Ladybug plugin, the result of the radiance study can be found in the figure below.

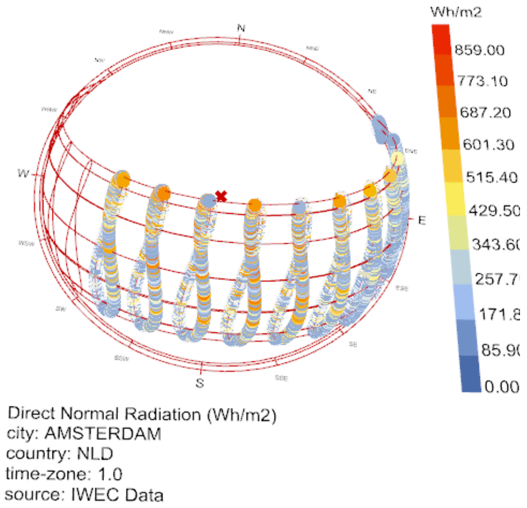


Figure 29 Result of the radiance study using the Ladybug plugin in Rhino.

$$Illuminance\ ratio = \frac{vertical\ illumiance}{horizontal\ illuminance}$$

Equation 1 Illuminance ratio.

Figure 30 Illuminance ratios for patient' room on floor 8.

To evaluate the overall illuminance ratio, a box plot with the accumulated data is shown below. The data was then divided into the different view directions, to be able to compare them. As the figure illustrates the average is around 0,06 to 1. Most view directions had similar values, but the Nd directions had double the average, Rg north and south had higher values as well. However, Nf had half the values of the overall average.

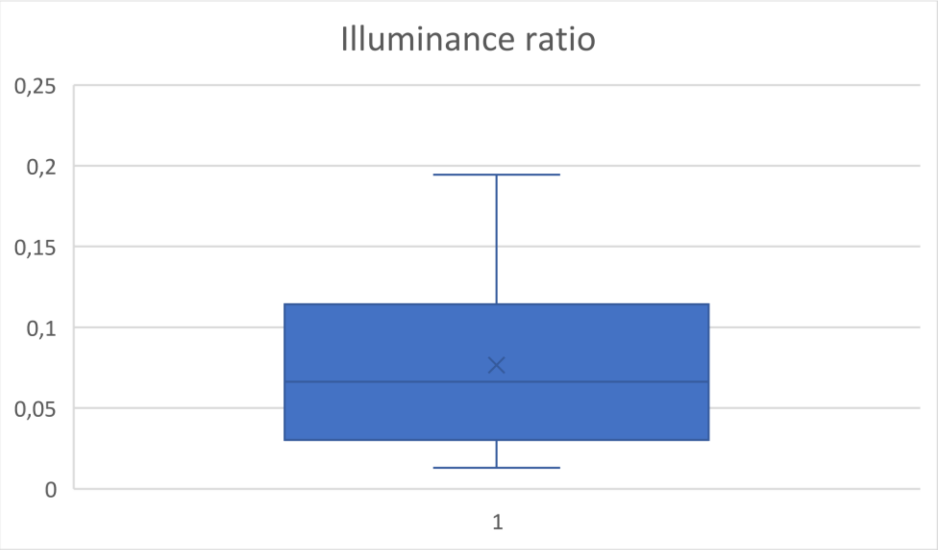


Figure 31 Illuminance ratio for all the researched rooms.

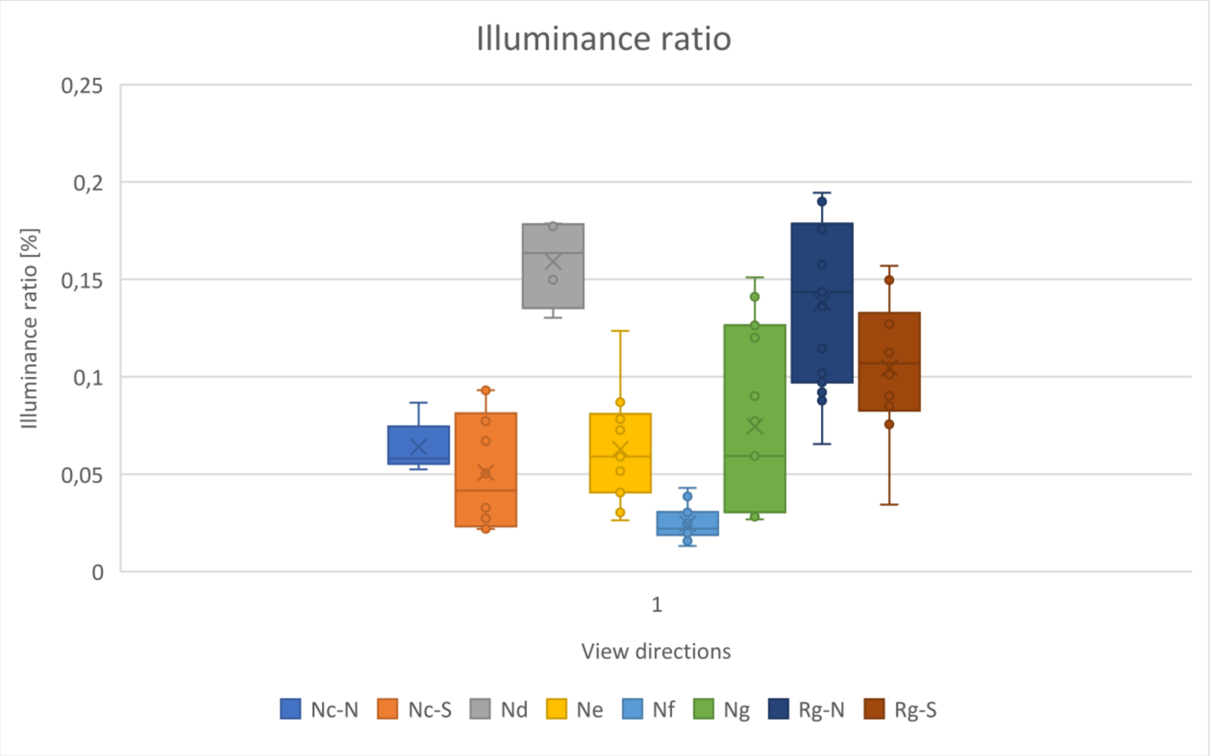


Figure 32 Illuminance ratio for all directions.

6.2.2 Luminance

The luminance values were retrieved from luminance mapping which were generated by using LMK Labsoft. In the program a luminance map was made for each individual window view and an average luminance value for each were given.

Figure 33 Map of floor 8 indicating the luminance values in the rooms.

The luminance values could be evaluated into more detail by comparing the box plots below, the first figure was from the accumulated luminance of all the rooms. The other figure shows the luminance from each of the view directions. The average luminance was around 900 cd/m2, the luminance values differ a lot for each of the view directions. What was remarkable is the Rg north and south direaction for these directions were high compared to the other 6 values, the average was nearly double the average of the other directions. The Ne direction was half the average of the other directions which could be caused due to the view composition, Ne view direction was composed mostly of buildings. Nf has low values average aswell which could be caused due to the fact of the roof garden in front of it.

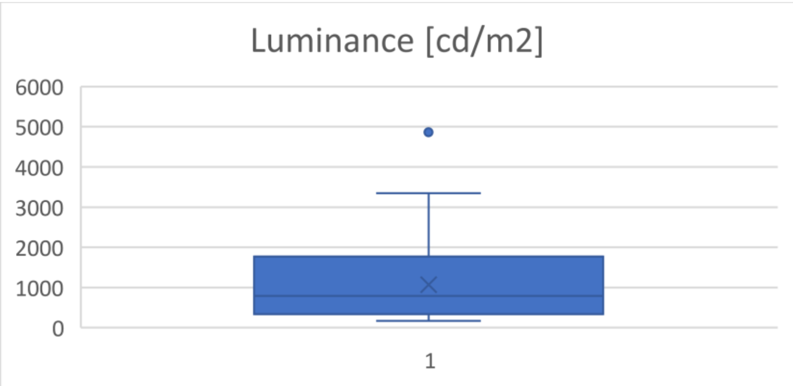


Figure 34 Luminance for all the researched rooms.

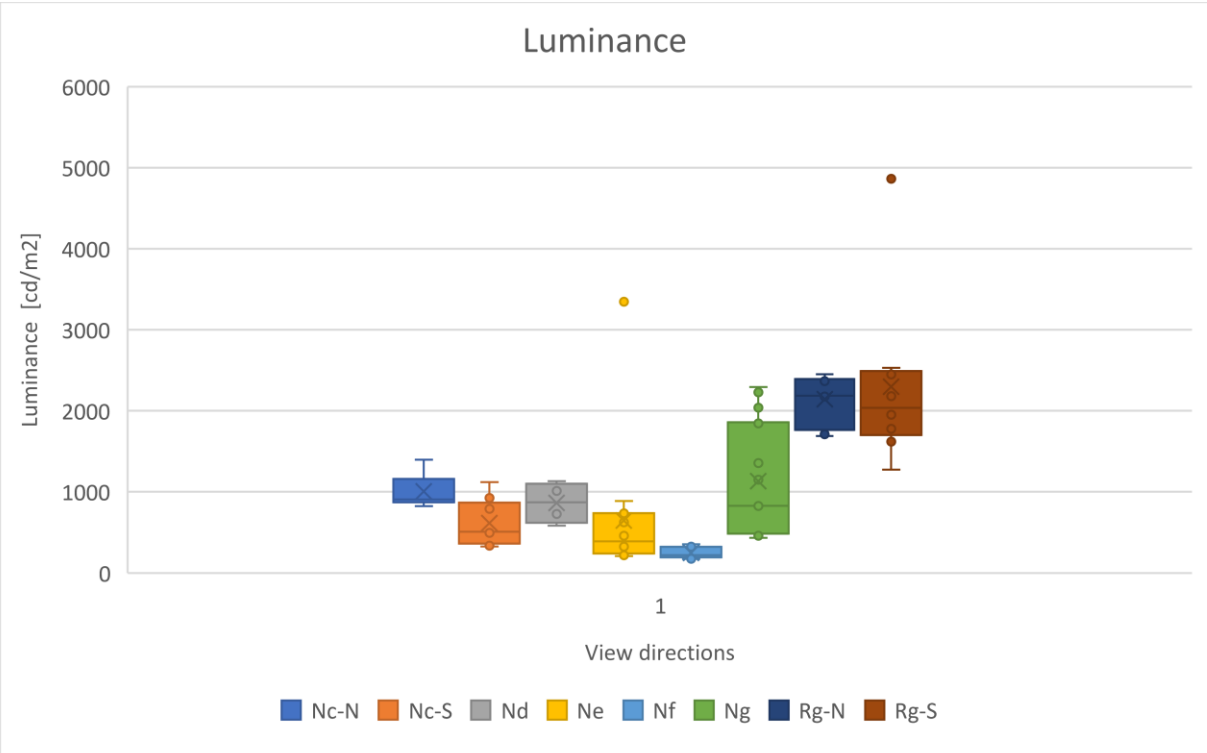


Figure 35 Luminance for all directions.

6.2.3 Daylight factor

The daylight factor was simulated in the 3D rhino model using the Honeybee plugin. For each of the 8 rooms a daylight factor simulation was made to get the daylight factor grid over the whole room. To check the values hand calculations were done using the formula shown below. In the table 6, the daylight factors for each of the rooms can be seen, the rooms daylight factor range from 1,9 % to 3,0%. To evaluate the daylight factor in the survey rooms, the minimum daylight factor for a recommended target illuminance is used. Table 7 is part of the table used in NEN-EN 17037, to evaluate the minimum daylight factor (NEN-EN 17037+A1, 2021). The table shows that for a target illuminance 300 lx, the daylight factor is 2,1%, the rooms Rg822 and Ne801 would not meet the required daylight factor. For the target illuminance of 500 lx, the daylight factor is 3,5%, none of the survey rooms would meet the daylight requirement.

$$DF = \frac{Twin * Awin * \theta sky}{Ain * (1 - Rin)}$$

Equation 2 Daylight factor formula.

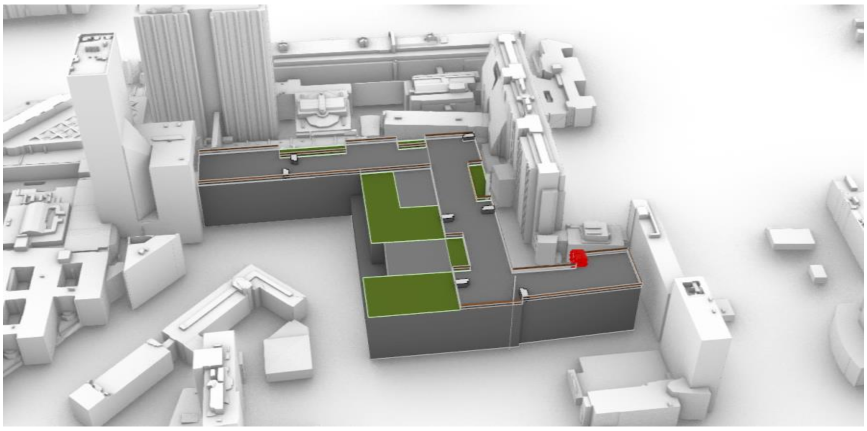


Figure 36 Honeybee daylight factor simulation.

Table 6 Daylight factor survey rooms.

Room number	Daylight factor [%]
Ng808	2,3
Rg 801	3,0
Rg822	2,0
Ng805	2,2
Ng 822	2,5
Ne 801	1,9
Nc831	2,6
Nc834	2,1

Table 7 Values of D for daylight openings to exceed an illuminance level of 100, 300, 500 or 750 lx for a fraction of daylight hours

Nation	Capitol	Geographical latitude	Median External Diffuse Illumiance Ev,d,med	D to exceed 100 lx	D to exceed 100 lx	D to exceed 100 lx	D to exceed 100 lx
The Netherlands	Amsterdam	52,3	14400	0,7%	2,1%	3,5%	5,2 %

6.3 Survey rooms

The survey rooms were evaluated on their composition, the views were divided into sky, buildings, street/water and greenery ratios. To compare the room composition the figure below could be used. The number on the left of the figures corresponds with the view of the hospital room used in the survey. In the figure could be seen that Ne 808 had the largest building percentage in the view composition, Ng 822 had the largest greenery percentage in the view composition and Nc831 has the largest sky composition.

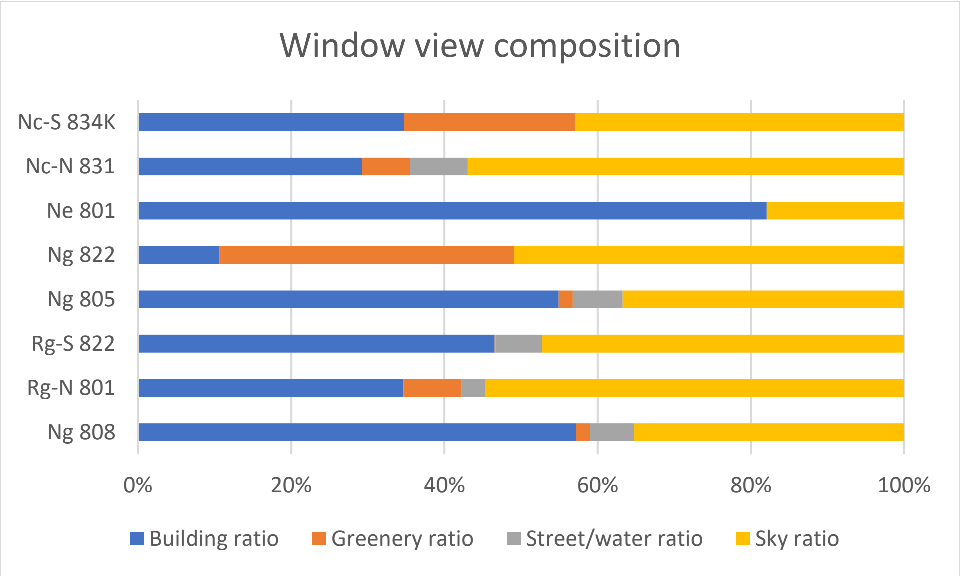


Figure 37 Window view composition of the selected rooms of the survey.

6.4 SSPS analysis

In the SSPS software the results of the survey were analyzed, in the analysis the rooms were scored individually on visual perception. Visual perception was represented in the survey as 2 variables, interest, and Pleasantness. In the figure below the average rating on pleasantness and interest shown for each room. Pleasantness and interest(novelty) are considered to be fundamental dimensions in evalutating aesthetics, pleasantness is considered to be the first initial evaluation of the views attractiveness, while interest is evaluated on wether the scenery can captivate the beholder and is often evaluated over abit longer time period then attractiveness (Karmanov & Hamel, 2008).

The graphs show that the values for interest and pleasantness for each room very similar. With the lowest rating for Rg822 and the highest rating for Nc 831. However the rating for Ng808, Rg801 and Ng 822 was similar to the highest rating rating, all these values where around a 5.8-5.9 average.

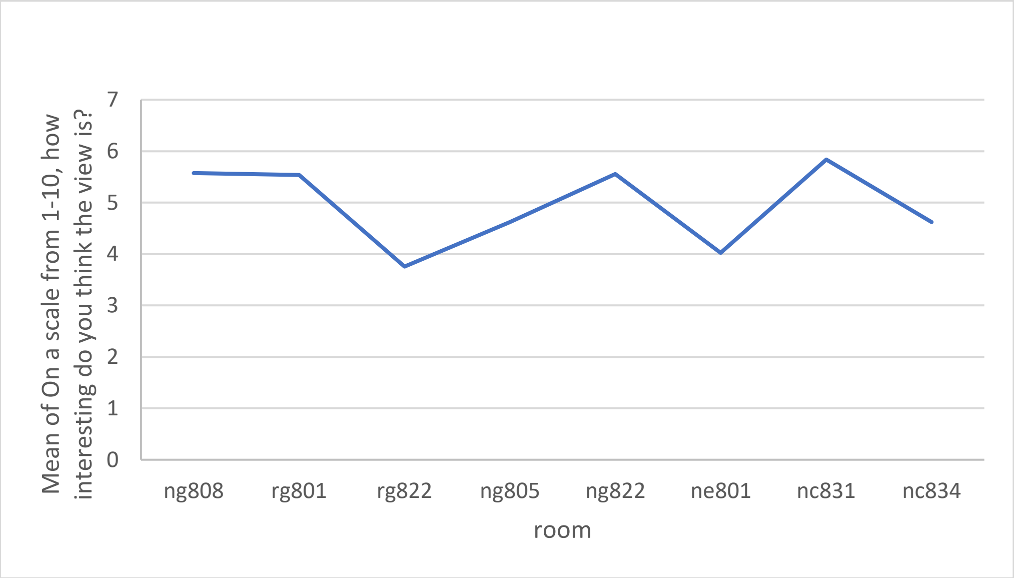


Figure 38 SSPS analyzes on average interest rating for each room.

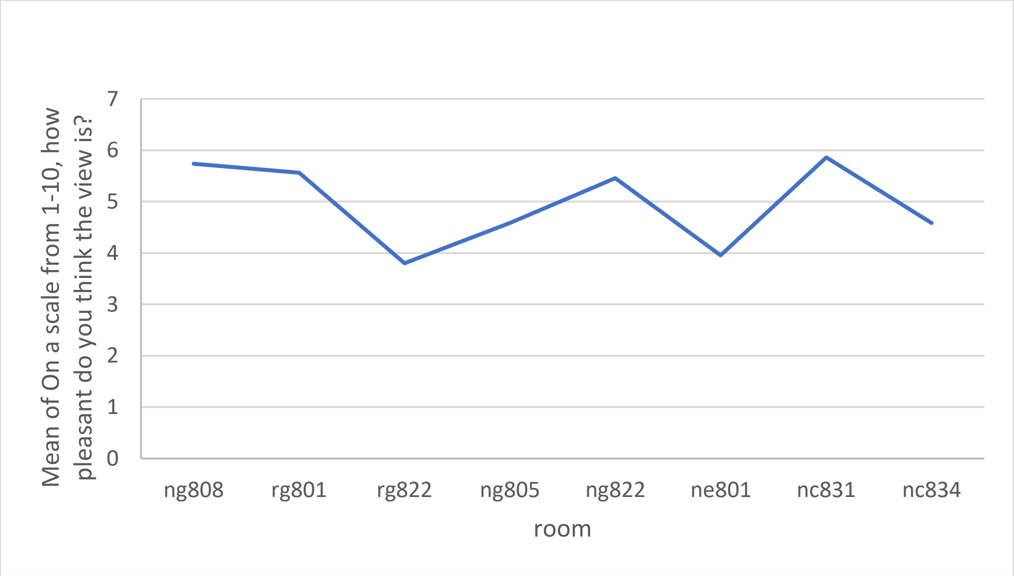


Figure 39 SSPS analyzes on average pleasantness rating for each room.

To be able to analyze the significance of the correlation between factors, the effect size is calculated for the relevant Pearson correlation values, by squaring the value. The effect size value is then categorize using the table 8 (Field, 2018).

Table 8 Effect size evaluation.

Range effect size	Effect size category
0.00 < 0.20	Weak
0.20 < 0.40	Moderate
0.40 < 0.60	Relative strong
0.60 < 0.80	Strong
0.80 < 1.00	Very strong

In NEN-EN 17037 the view is mainly evaluated on the presence of the 3 layers: sky, landscape and ground layer. The assumed relevance of these layers was evaluated with a Pearson correlation analysis. The figure shows that there is a significant correlation between the layers and the interest / pleasantness rating of the participants. The significant correlation is highlighted in blue in the figure below. The effect size for interest and pleasantness were both rounded to 0.02, which categorize the effect size as weak.

Correlations

				layers
On a scale from 1-10, how interesting do you think the view is?	Pearson Correlation			.145**
	Sig. (2-tailed)			.008
	N			337
	Bootstrap[c]	Bias		-.002
		Std. Error		.057
		95% Confidence Interval	Lower	.027
			Upper	.249
On a scale from 1-10, how pleasant do you think the view is?	Pearson Correlation			.157**
	Sig. (2-tailed)			.004
	N			337
	Bootstrap[c]	Bias		-.003
		Std. Error		.055
		95% Confidence Interval	Lower	.042
			Upper	.256

**. Correlation is significant at the 0.01 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Figure 40 Correlation pleasantness/interest with the number of layers in the view.

In figure 41, view factors and daylight parameters are analyzed on their correlation with the interest and pleasantness of the survey participants. For pleasantness the building ratio, sky ratio and the distance had a significant correlation. All three of the factors had a weak effect size. Where building ratio was negative significant correlation and sky ratio was positive significant correlation. For the interest the correlation was similar however the green ratio had a low significant correlation as well. The luminance and illuminance ratio had no correlation with the pleasantness and interesting ratings.

Correlations

				building_ratio	greenery_ratio	sky_ratio	streets _water _ratio	distance	luminance	ratio_illuminance veritical/horizontal
On a scale from 1-10, how pleasant do you think the view is?	Pearson Correlation			-.170**	.102	.194**	.074	.227**	.030	-.003
	Sig. (2-tailed)			.002	.062	<,001	.176	<,001	.578	.957
	N			337	337	337	337	337	337	337
	Bootstrap[c]	Bias		.003	-.004	-.001	.002	-.003	.002	.002
		Std. Error		.055	.056	.052	.054	.054	.058	.055
		95% Confidence Interval	Lower	-.273	-.011	.086	-.035	.118	-.093	-.113
			Upper	-.058	.208	.293	.183	.330	.143	.103
On a scale from 1-10, how interesting do you think the view is?	Pearson Correlation			-.171**	.116*	.192**	.055	.215**	.008	-.019
	Sig. (2-tailed)			.002	.034	<,001	.310	<,001	.883	.734
	N			337	337	337	337	337	337	337
	Bootstrap[c]	Bias		.002	-.003	-.001	.000	-.003	.001	.001
		Std. Error		.056	.054	.053	.053	.053	.059	.056
		95% Confidence Interval	Lower	-.278	.008	.083	-.051	.105	-.111	-.129
			Upper	-.062	.218	.293	.163	.314	.117	.086

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Figure 41 Correlation pleasantness/interest with the view factors and daylight parameters.

From the correlation figure 41, the significance of the view factors correlation was apparent, however the daylight factors didn't have any significant correlation with the perception of the participants. Whether the view factor and the daylight parameters had any correlation between each other can be found in the figure 42. The green ratio has a significant negative correlation and a weak to moderate effect size, while the street/water and sky ratio have a positive correlation. Where sky ratio had a weak effect size and street/water ratio had a moderate effect size. The building ratio has no significant correlation with the daylight parameters.

Correlations

					luminance	ratio_illuminance veritical/horizontal
building_ratio	Pearson Correlation				-.061	.075
	Sig. (2-tailed)				.140	.068
	N				592	592
	Bootstrap[c]	Bias			.002	.002
		Std. Error			.040	.030
		95% Confidence Interval	Lower		-.134	.016
			Upper		.024	.137
greenery_ratio	Pearson Correlation				-.436**	-.495**
	Sig. (2-tailed)				<,001	<,001
	N				592	592
	Bootstrap[c]	Bias			-.001	-.001
		Std. Error			.023	.018
		95% Confidence Interval	Lower		-.481	-.533
			Upper		-.393	-.459
streets _water _ratio	Pearson Correlation				.546**	.386**
	Sig. (2-tailed)				<,001	<,001
	N				592	592
	Bootstrap[c]	Bias			.000	.001
		Std. Error			.024	.028
		95% Confidence Interval	Lower		.498	.334
			Upper		.594	.444
sky_ratio	Pearson Correlation				.334**	.267**
	Sig. (2-tailed)				<,001	<,001
	N				592	592
	Bootstrap[c]	Bias			-.001	-.001
		Std. Error			.031	.029
		95% Confidence Interval	Lower		.268	.208
			Upper		.392	.324

**. Correlation is significant at the 0.01 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Figure 42 Correlation between the view factor ratios and the luminance/ illuminance ratio.

To get a better overview of the importance of the components of the layers, a correlation analysis was conducted between the participants perception, layers, and the view factors ratios. In the figure 43 can be seen that except for the street/water ratio the correlation of the values were comparable. Notable is the significance of the correlation for the layers is higher than that of the interest and pleasantness. The effect size for the pleasantness and interest was weak, while the effect size for the layers was for greenery ratio weak and for the other factors moderate to strong.

Correlations

				building_ratio	greenery_ratio	streets _water _ratio	sky_ratio
On a scale from 1-10, how interesting do you think the view is?	Pearson Correlation			-.171**	.116*	.055	.192**
	Sig. (2-tailed)			.002	.034	.310	<,001
	N			337	337	337	337
	Bootstrap^c	Bias		.002	-.003	.000	-.001
		Std. Error		.056	.054	.053	.053
		95% Confidence Interval	Lower	-.278	.008	-.051	.083
			Upper	-.062	.218	.163	.293
On a scale from 1-10, how pleasant do you think the view is?	Pearson Correlation			-.170**	.102	.074	.194**
	Sig. (2-tailed)			.002	.062	.176	<,001
	N			337	337	337	337
	Bootstrap^c	Bias		.003	-.004	.002	-.001
		Std. Error		.055	.056	.054	.052
		95% Confidence Interval	Lower	-.273	-.011	-.035	.086
			Upper	-.058	.208	.183	.293
layers	Pearson Correlation			-.800**	.286**	.445**	.731**
	Sig. (2-tailed)			<,001	<,001	<,001	<,001
	N			337	337	337	337
	Bootstrap^c	Bias		.001	.000	-.001	-.001
		Std. Error		.022	.022	.032	.026
		95% Confidence Interval	Lower	-.838	.245	.380	.678
			Upper	-.751	.329	.508	.778

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Figure 43 Correlation between participants perception, layers and the view factors.

However, when we compare the correlation between the participant perception and the daylight parameters it has none significance correlation, in contrast to the correlation between the layers and the daylight parameters which has positive significance and a weak effect size.

Correlations

				building_ratio	greenery_ratio	streets _water _ratio	sky_ratio	luminance	ratio_illuminance veritical/horizontal
On a scale from 1-10, how interesting do you think the view is?	Pearson Correlation			-.171**	.116*	.055	.192**	.008	-.019
	Sig. (2-tailed)			.002	.034	.310	<,001	.883	.734
	N			337	337	337	337	337	337
	Bootstrap^c	Bias		.002	-.003	.000	-.001	.001	.001
		Std. Error		.056	.054	.053	.053	.059	.056
		95% Confidence Interval	Lower	-.278	.008	-.051	.083	-.111	-.129
			Upper	-.062	.218	.163	.293	.117	.086
On a scale from 1-10, how pleasant do you think the view is?	Pearson Correlation			-.170**	.102	.074	.194**	.030	-.003
	Sig. (2-tailed)			.002	.062	.176	<,001	.578	.957
	N			337	337	337	337	337	337
	Bootstrap^c	Bias		.003	-.004	.002	-.001	.002	.002
		Std. Error		.055	.056	.054	.052	.058	.055
		95% Confidence Interval	Lower	-.273	-.011	-.035	.086	-.093	-.113
			Upper	-.058	.208	.183	.293	.143	.103
layers	Pearson Correlation			-.800**	.286**	.445**	.731**	.416**	.178**
	Sig. (2-tailed)			<,001	<,001	<,001	<,001	<,001	.001
	N			337	337	337	337	337	337
	Bootstrap^c	Bias		.001	.000	-.001	-.001	-.001	-.001
		Std. Error		.022	.022	.032	.026	.028	.021
		95% Confidence Interval	Lower	-.838	.245	.380	.678	.360	.137
			Upper	-.751	.329	.508	.778	.469	.219

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Figure 44 Correlation between participants perception, layers, and the view factor with addition to the daylight parameters.

To know whether there is correlation between the different factors and parameters which could have influenced, a correlation analysis was performed and can be found below. In the figure 45, the confidence intervals of the correlation can be found. From the table can be found there were indeed significant correlation between the view factors and daylight parameter, except between the building ratio and street/water ratio, as well as building ratio and the daylight parameters.

For the building ratio the factor which had a significant correlation, had a relatively strong to strong effect size. The greenery ratio and the street/ratio had weak to moderate effect size with the significant correlation factors, except between the greenery ratio and the building ratio.

For the layer (NEN-EN criterion), the relative strong to strong effect size correlations were the building and the sky ratio.

In figure 46, the confidence intervals of the Pearson correlation analysis are presented. The values are compared to the values of figure 48, to evaluate to possible representation of the survey rooms for the total researched rooms in the hospital.

Correlations

		building_ratio	greenery_ratio	streets _water _ratio	sky_ratio	layers	luminance	ratio_illuminance veritical/horizontal
building_ratio	Pearson Correlation	1	-.714**	-.008	-.871**	-.802**	-.061	.075
	Sig. (2-tailed)		<,001	.839	<,001	<,001	.140	.068
	N	592	592	592	592	592	592	592
greenery_ratio	Pearson Correlation	-.714**	1	-.593**	.397**	.283**	-.436**	-.495**
	Sig. (2-tailed)	<,001		<,001	<,001	<,001	<,001	<,001
	N	592	592	592	592	592	592	592
streets _water _ratio	Pearson Correlation	-.008	-.593**	1	.301**	.452**	.546**	.386**
	Sig. (2-tailed)	.839	<,001		<,001	<,001	<,001	<,001
	N	592	592	592	592	592	592	592
sky_ratio	Pearson Correlation	-.871**	.397**	.301**	1	.732**	.334**	.267**
	Sig. (2-tailed)	<,001	<,001	<,001		<,001	<,001	<,001
	N	592	592	592	592	592	592	592
layers	Pearson Correlation	-.802**	.283**	.452**	.732**	1	.422**	.186**
	Sig. (2-tailed)	<,001	<,001	<,001	<,001		<,001	<,001
	N	592	592	592	592	592	592	592
luminance	Pearson Correlation	-.061	-.436**	.546**	.334**	.422**	1	.923**
	Sig. (2-tailed)	.140	<,001	<,001	<,001	<,001		<,001
	N	592	592	592	592	592	592	592
ratio_illuminance veritical/horizontal	Pearson Correlation	.075	-.495**	.386**	.267**	.186**	.923**	1
	Sig. (2-tailed)	.068	<,001	<,001	<,001	<,001	<,001	
	N	592	592	592	592	592	592	592

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 45 Correlation view factors and daylight parameters.

Confidence Intervals

	Pearson Correlation	Sig. (2-tailed)	95% Confidence Intervals (2-tailed) [a]	
			Lower	Upper
building_ratio - greenery_ratio	-.714	<,001	-.751	-.672
building_ratio - streets _water _ratio	-.008	.839	-.089	.072
building_ratio - sky_ratio	-.871	<,001	-.889	-.849
building_ratio - layers	-.802	<,001	-.829	-.771
building_ratio - luminance	-.061	.140	-.141	.020
building_ratio - ratio_illuminance veritical/horizontal	.075	.068	-.006	.155
greenery_ratio - streets _water _ratio	-.593	<,001	-.643	-.538
greenery_ratio - sky_ratio	.397	<,001	.326	.462
greenery_ratio - layers	.283	<,001	.206	.355
greenery_ratio - luminance	-.436	<,001	-.498	-.368
greenery_ratio - ratio_illuminance veritical/horizontal	-.495	<,001	-.553	-.431
streets _water _ratio - sky_ratio	.301	<,001	.226	.373
streets _water _ratio - layers	.452	<,001	.385	.514
streets _water _ratio - luminance	.546	<,001	.486	.600
streets _water _ratio - ratio_illuminance veritical/horizontal	.386	<,001	.315	.452
sky_ratio - layers	.732	<,001	.692	.767
sky_ratio - luminance	.334	<,001	.261	.404
sky_ratio - ratio_illuminance veritical/horizontal	.267	<,001	.190	.340
layers - luminance	.422	<,001	.353	.485
layers - ratio_illuminance veritical/horizontal	.186	<,001	.107	.263
luminance - ratio_illuminance veritical/horizontal	.923	<,001	.910	.934

a. Estimation is based on Fisher's r-to-z transformation with bias adjustment.

Figure 46 Confidence intervals for the correlation view factors and daylight parameters.

To compare the accuracy of the correlation between the view factors and daylight parameters, a correlation analysis was conducted between these values over the total number of rooms evaluated in the study. The results can be found in the figure 47. The figure shows the same significance correlation as figure 45 does, the only difference was that there is no significant correlation between the sky ratio and the greenery ratio. The building ratio had moderate to relatively strong effect size with the significant correlation factors, which means the effect size has decreased in comparison to figure 45. The greenery and street/water ratio has still weak to moderate effect size, however the overall significance of the correlation has decreased in comparison to figure 45.

For the layer (NEN-EN criterion), the weak to moderate effect size correlations for all factors and daylight parameters.

Correlations

				building_ratio	greenery_ratio	streets _water_ratio	sky_ratio	layers	luminance	Ratio_illuminance
building_ratio	Pearson Correlation			1	-.526**	-.074	-.637**	-.489**	-.023	.000
	Sig. (2-tailed)				<,001	.504	<,001	<,001	.837	.999
	N			85	85	85	85	85	85	85
	Bootstrap[c]	Bias		0	.002	.006	-.001	-.001	-.008	.003
		Std. Error		0	.061	.085	.078	.136	.112	.087
		95% Confidence Interval	Lower	1	-.635	-.225	-.769	-.743	-.241	-.176
			Upper	1	-.390	.112	-.476	-.217	.190	.169
greenery_ratio	Pearson Correlation			-.526**	1	-.320**	.182	.445**	-.221*	-.239*
	Sig. (2-tailed)			<,001		.003	.095	<,001	.043	.028
	N			85	85	85	85	85	85	85
	Bootstrap[c]	Bias		.002	0	.001	-.003	.003	.003	.001
		Std. Error		.061	0	.056	.093	.047	.080	.086
		95% Confidence Interval	Lower	-.635	1	-.424	-.029	.356	-.361	-.394
			Upper	-.390	1	-.208	.349	.542	-.051	-.061
streets _water _ratio	Pearson Correlation			-.074	-.320**	1	.498**	.392**	.493**	.276*
	Sig. (2-tailed)			.504	.003		<,001	<,001	<,001	.010
	N			85	85	85	85	85	85	85
	Bootstrap[c]	Bias		.006	.001	0	-.005	.000	.005	.004
		Std. Error		.085	.056	0	.072	.049	.080	.080
		95% Confidence Interval	Lower	-.225	-.424	1	.339	.300	.331	.115
			Upper	.112	-.208	1	.628	.490	.644	.447
sky_ratio	Pearson Correlation			-.637**	.182	.498**	1	.582**	.399**	.305**
	Sig. (2-tailed)			<,001	.095	<,001		<,001	<,001	.005
	N			85	85	85	85	85	85	85
	Bootstrap[c]	Bias		-.001	-.003	-.005	0	-.006	.009	.001
		Std. Error		.078	.093	.072	0	.078	.091	.097
		95% Confidence Interval	Lower	-.769	-.029	.339	1	.413	.235	.108
			Upper	-.476	.349	.628	1	.711	.594	.495
layers	Pearson Correlation			-.489**	.445**	.392**	.582**	1	.354**	.243*
	Sig. (2-tailed)			<,001	<,001	<,001	<,001		<,001	.025
	N			85	85	85	85	85	85	85
	Bootstrap[c]	Bias		-.001	.003	.000	-.006	0	.009	-.001
		Std. Error		.136	.047	.049	.078	0	.088	.077
		95% Confidence Interval	Lower	-.743	.356	.300	.413	1	.169	.096
			Upper	-.217	.542	.490	.711	1	.515	.398
luminance	Pearson Correlation			-.023	-.221*	.493**	.399**	.354**	1	.647**
	Sig. (2-tailed)			.837	.043	<,001	<,001	<,001		<,001
	N			85	85	85	85	85	85	85
	Bootstrap[c]	Bias		-.008	.003	.005	.009	.009	0	.019
		Std. Error		.112	.080	.080	.091	.088	0	.124
		95% Confidence Interval	Lower	-.241	-.361	.331	.235	.169	1	.428
			Upper	.190	-.051	.644	.594	.515	1	.893
Ratio_illuminance	Pearson Correlation			.000	-.239*	.276*	.305**	.243*	.647**	1
	Sig. (2-tailed)			.999	.028	.010	.005	.025	<,001	
	N			85	85	85	85	85	85	85
	Bootstrap[c]	Bias		.003	.001	.004	.001	-.001	.019	0
		Std. Error		.087	.086	.080	.097	.077	.124	0
		95% Confidence Interval	Lower	-.176	-.394	.115	.108	.096	.428	1
			Upper	.169	-.061	.447	.495	.398	.893	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Figure 47 Correlation view factors and daylight parameters for whole data set.

Confidence Intervals

	Pearson Correlation	Sig. (2-tailed)	95% Confidence Intervals (2-tailed) [a]	
			Lower	Upper
building_ratio - greenery_ratio	-.526	<,001	-.664	-.352
building_ratio - streets _water _ratio	-.074	.504	-.282	.142
building_ratio - sky_ratio	-.637	<,001	-.748	-.490
building_ratio - layers	-.489	<,001	-.636	-.308
building_ratio - luminance	-.023	.837	-.235	.191
building_ratio - Ratio_illuminance	.000	.999	-.213	.213
greenery_ratio - streets _water _ratio	-.320	.003	-.499	-.114
greenery_ratio - sky_ratio	.182	.095	-.032	.380
greenery_ratio - layers	.445	<,001	.256	.601
greenery_ratio - luminance	-.221	.043	-.414	-.008
greenery_ratio - Ratio_illuminance	-.239	.028	-.430	-.027
streets _water _ratio - sky_ratio	.498	<,001	.318	.643
streets _water _ratio - layers	.392	<,001	.195	.558
streets _water _ratio - luminance	.493	<,001	.312	.639
streets _water _ratio - Ratio_illuminance	.276	.010	.067	.462
sky_ratio - layers	.582	<,001	.421	.707
sky_ratio - luminance	.399	<,001	.203	.564
sky_ratio - Ratio_illuminance	.305	.005	.098	.486
layers - luminance	.354	<,001	.152	.527
layers - Ratio_illuminance	.243	.025	.032	.434
luminance - Ratio_illuminance	.647	<,001	.503	.756

a. Estimation is based on Fisher's r-to-z transformation.

Figure 48 Confidence intervals for the correlation view factors and daylight parameters for the whole data set.

7. Discussion

The research analysis carried out in this thesis was primarily based on pictures taken in the Erasmus MC (as explained in chapter 5.1). These pictures were analyzed in several ways to get all the necessary view factors and daylight parameters. The pictures were taken over several days, the days were selected on availability of the researchers and the Erasmus Mc and the sky condition. All the pictures were taken under an overcast sky condition. However due to the fact that the sky conditions change continuously over the day, the sky condition vary over the pictures of the data base within the limits of an overcast sky. This could have some influence on the perception of the photos in the survey and the daylight parameter values in the analyses. For example the participants could perceive the views more gloomy due to the difference in daylight. The retrieved values from the survey and data analyses are then used in the correlation analysis of the view factors and daylight parameters, visual perception and NEN – EN 17037 number of layers.

The NEN-EN 17037 consists of a simple matrix to assess the view based on 3 parameters, horizontal sight angle, outside distance of the view and number of layers. To evaluate the validity and inclusivity of these 3 parameters, other view factors and daylight parameters were tested. From the results, it could be concluded that the used layers were indeed important. However, the NEN criterion does not include any minimum layer size for it to be counted as present. The matrix does not include a percentage quantification for each of the present layers, which can lead to views with the same evaluation but with very different view compositions.

The NEN matrix is constructed out of the data from several research reports, one of the more prominent research papers is from Hellinga and Hordijk (Hellinga & Hordijk, 2014). The pictures used in the evaluation in this research are shown in ´Appendix NEN-EN 17037 based pictures´. Large amount of the pictures shows a green landscape type view, which is often not present in the views from city and urban environments, which is the case for environment of the present research.

The discrepancy between the views used in the research behind the NEN matrix and the views found in urban environments begs the question of whether the surrounding area of the buildings should be included as a factor in the NEN. A suggestion for the new NEN criteria matrix for the 'View outwards' assessment, with the newly found results of this thesis, is presented in figure 49. In the matrix the layers were divided in more relevant view components, the percentage of each view component was evaluated, therefore the components were evaluated not simply based on their presence in the view but also based on the percentage they occupy in the view (percentage-based value). The daylight parameters as shown in figure 42 correlate with the different view components, hence this correlation should be accounted for in the matrix (daylight parameter impact factor). However, the correlation between the daylight parameters and each possible view component should be evaluated in more detail in further research. Also, the effect of the surrounding area of the building should be taken into account in the matrix (location impact factor).

	Horizontal sight angle	Distance	Building ratio	Sky ratio	Greenery ratio	Street/water ratio
Percentage based value						
Day light parameter Impact factor						
Location factor impact factor						
Score						
Overall score						

Figure 49 Suggested table for the NEN -EN view outward assessment.

The survey used in this thesis to evaluate the visual perception is based on the window views of the Erasmus Mc in Rotterdam. 42 to 50 participants answered the survey, which covered all view directions. For a more accurate representation of the population the survey should be repeated with a higher number of participants. Also, the survey was focused on window views of a hospital which was communicated to the participants, see 'Appendix conducted survey'. The participants filled in the survey with a certain prejudgment on how they feel a hospital window should look like. So, for further research would be recommended to take multiple surveys which showcase each a different building occupation type. As a result, the type of occupation in buildings can play another factor in the evaluation of the view.

The survey distribution did not target a particular population, hence the low participation rate of people working in the health profession. For further research the survey should be limited to the possible users of the building, to gather opinions on window view that are more closely linked to the actual use of the building. In the case of the hospital, the participants would include the patients, nurses, doctors and family/ friends' caregivers.

The results found in this thesis could be implemented into the current hospital design as improvement of the program of requirements. The view outwards should be evaluated as the suggested matrix presented in figure 49. With this improved evaluation of the view outwards, a more detailed assessment could be made. With the new evaluation results the room's view directions could be ranked and then matched to the existing hospital departments. The departments hosting patients with the highest illness severity should be matched with the highest-ranking window views. Since patients who are struggling the most with their health benefit the most from the high-ranking window views. Since the location of hospital buildings is often determined by the city grid, it cannot be chosen based on the optimal view outward assessment. However, the area around the hospital could be designed to benefit the window views by incorporating more greenery into the pathways around the hospital or even create small parks or sitting areas around it. Even for existing hospital buildings incorporating green in the environment and the building itself would improve the view outward assessment in a positive way. An example would be the Erasmus Mc which was renovated in 2018 to incorporate green roofs into the building. Green roofs are just one example of the possibilities to include more green elements in the views of the hospital. Another example would be vertical gardens which could be installed with a frame on existing exterior and interior walls.

8. Conclusion

The research strove to answer the question: “Which relevant factors related to the view to the outside and/or to daylight parameters influence the visual perception of people?”. To be able to answer this relative broad question, four sub questions were composed next to the main one.

The first sub question was “Is there a difference in pleasantness and or interest between rooms with different orientations?”. In section 6.4, the results from the SSPS analysis, which can be seen in figure 38 and 39, show that there is indeed a difference between the rooms of the hospital, since each of the rooms represent one of the view directions, it can be said that orientation influence the rating for pleasantness and interest. Pleasantness and interest were rated rather similarly, which would suggest the participants interpreted them as attributes.

The second sub question was “Do daylight parameters influence the pleasantness and or interest rating?”. Figure 41 shows that the daylight parameters do not have a significant correlation with the pleasantness and interest rating. However, figure 44 show the significant correlation between the number of the layers (NEN matrix criterion) and the daylight factors.

The Third sub question was “Do view parameters influence the pleasantness and or interest rating?”. Figure 44 shows there is a significancy in the correlation between the building ratio, sky ratio and the pleasantness rating, also the interest rating had significancy in the correlation with these view factors and the greenery ratio.

The fourth sub question was “Is there an interaction between view and daylight parameters influencing pleasantness and or interest rating?”. The results shown in figure 45 show that there is indeed a significant correlation between certain view factors and daylight parameters, also the view factors have significant correlation between each other.

One additional test proved that the images chosen for the survey are a representative subset of the complete dataset made of views from the 94 rooms. When figure 46 is compared to figure 48, it can be concluded that the survey rooms intervals are within the intervals of the larger data set. Therefore, the conclusion made from the correlation connections of the survey data set is that the chosen subset can be used to represent the dataset of the total researched rooms.

With these new findings, changes to the current NEN can be suggested. According to the research, the layers already evaluated in the NEN are important. However, the layers should be judged on the percentages they take up in the view rather than just being counted as present or absent. The layers were also found to be too broad and vague; it is recommended to divide the layers into multiple aspects (such as street, water and greenery) with a clear description of the content of these new aspect. The impact of each of these aspects on the visual perception should be included in the evaluation of the view.

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Appendix collected data

View factor overall data set

ID	Building part	Room	Building ratio (%)	Greenery ratio (%)	Street/water ratio (%)	Sky Ratio (%)	Distance (m)	Composition horizontal layer	Far away element	Human presence	Layers	Sky layer	Building layer	Ground layer
1	C	829	15,1	3,1	3,5	27,2	64	Yes	Yes	Yes	3	Yes	Yes	Yes
2	C	830K	24,8	5,0	0,0	16,2	52	Yes	Yes	No	3	Yes	Yes	No
3	C	831	13,9	3,0	3,6	27,1	66	Yes	Yes	Yes	3	Yes	Yes	Yes
4	C	832K	15,5	5,3	0,0	16,1	50	Yes	Yes	No	3	Yes	Yes	No
5	C	833	14,9	3,2	3,5	27,7	69	Yes	Yes	Yes	3	Yes	Yes	Yes
6	C	834K	14,8	9,5	0,0	18,2	54	Yes	Yes	No	3	Yes	Yes	No
7	C	839	17,0	3,4	3,6	27,1	76	Yes	Yes	Yes	3	Yes	Yes	Yes
8	C	840K	13,5	6,7	0,0	18,7	54	Yes	Yes	No	3	Yes	Yes	No
9	C	841	16,0	3,4	3,2	27,0	78	Yes	Yes	Yes	3	Yes	Yes	Yes
10	C	842K	13,1	5,5	0,0	19,7	54	Yes	Yes	No	3	Yes	Yes	No
11	C	843	16,9	3,6	3,2	26,8	81	Yes	Yes	Yes	3	Yes	Yes	Yes
12	C	844K	13,7	6,0	0,0	19,4	54	Yes	Yes	No	3	Yes	Yes	No
13	C	846K	14,3	9,9	0,0	19,4	54	Yes	Yes	No	3	Yes	Yes	No
14	C	848K	16,8	10,5	0,0	17,0	54	Yes	Yes	No	3	Yes	Yes	No
15	C	850K	21,7	9,9	0,0	13,8	54	Yes	Yes	No	3	Yes	Yes	No
16	C	852K	x	X	x	x	54	Yes	Yes	No	3	Yes	Yes	No
17	D	831	x	X	x	x	54	x	X	x	x	x	x	x
18	D	833	x	X	x	x	54	x	X	X	x	x	x	x
19	D	835	x	X	x	x	54	x	X	X	x	x	x	x
20	D	836K	18,4	6,5	0,0	16,6	55	Yes	Yes	No	3	Yes	Yes	No
21	D	837	x	X	x	x	55	x	X	X	x	x	x	x
22	D	838K	x	X	x	x	55	x	X	X	x	x	x	x
23	D	839	x	X	x	x	55	x	X	x	x	x	x	x
24	D	840K	x	X	x	x	55	x	X	x	x	x	x	x
25	D	840K	x	X	x	x	55	x	X	X	x	x	x	x

26	D	841	19,9	6,6	0,0	16,2	52	Yes	Yes	No	3	Yes	Yes	No
27	D	842K	x	X	x	x	51	x	X	x	x	x	x	X
28	D	843	23,4	3,6	0,0	14,1	51	Yes	Yes	No	3	Yes	Yes	No
29	D	844K	x	X	x	x	51	x	X	X	x	x	x	x
30	D	845	x	X	x	x	51	x	X	x	x	x	x	x
31	D	847	x	X	x	x	51	X	X	X	x	x	x	x
32	D	849	x	X	x	x	51	X	X	x	x	x	x	x
33	E	851	x	X	x	x	51	X	X	x	x	x	x	x
34	E	1101	x	X	x	x	67	X	X	x	x	x	x	x
35	E	1104	x	X	x	x	67	X	X	x	x	x	x	x
36	F	1115	x	X	x	x	67	X	X	x	x	x	x	x
37	F	1103	x	X	x	x	68	X	X	X	x	x	x	x
38	G	1106	x	X	x	x	67	X	X	x	x	x	x	x
39	NC	1102	13,3	2,4	3,7	26,6	60	Yes	Yes	Yes	3	Yes	Yes	Yes
40	NC	923	9,0	1,4	0,0	1,5	57	No	No	No	1	No	Yes	No
41	ND	942	17,5	1,7	0,0	19,5	111	No	Yes	Yes	3	Yes	Yes	No
42	NE	939	45,9	0	0,0	10,0	25	No	No	No	2	Yes	Yes	No
43	NE	801	44,5	0	0,0	9,4	25	No	No	No	2	Yes	Yes	No
44	NE	803	29,9	0	0,0	5,9	25	No	No	No	2	Yes	Yes	No
45	NE	805	39,7	0	0,0	7,5	25	No	No	No	2	Yes	Yes	No
46	NE	807	39,8	0	0,0	7,6	25	No	No	No	2	Yes	Yes	No
47	NE	809	43,8	0	0,0	8,7	25	No	No	No	2	Yes	Yes	No
48	NE	811	43,5	0	0,0	9,5	25	No	No	No	2	Yes	Yes	No
49	NE	813	46,6	0	0,0	11,2	25	No	No	No	2	Yes	Yes	No
50	NE	815	42,6	0	0,0	12,8	25	No	No	No	2	Yes	Yes	No
51	NE	901	45,2	0	0,0	13,9	25	No	No	No	2	Yes	Yes	No
52	NE	903	41,6	0	0,0	12,1	25	No	No	No	2	Yes	Yes	No
53	NE	905	43,3	0	0,0	12,9	25	No	No	No	2	Yes	Yes	No
54	NE	907	40,2	0	0,0	11,3	25	No	No	No	2	Yes	Yes	No
55	NE	909	43,0	0	0,0	13,0	25	No	No	No	2	Yes	Yes	No
56	NE	913	40,4	0,0	0,0	11,8	25	No	No	No	2	Yes	Yes	No
57	NF	915	23,5	5,8	0,0	9,7	49	Yes	No	No	3	Yes	Yes	No

58	NF	803	17,3	0,0	0,0	15,3	123	Yes	Yes	Yes	2	Yes	Yes	No
59	NF	804	19,1	10,2	0,0	11,7	49	Yes	No	No	3	Yes	Yes	No
60	NF	805	11,9	0,0	0,0	17,5	121	Yes	Yes	Yes	2	Yes	Yes	No
61	NF	806	18,8	11,8	0,0	12,5	49	Yes	No	No	3	Yes	Yes	No
62	NF	807	18,1	9,2	0,0	13,4	49	Yes	No	No	3	Yes	Yes	No
63	NF	809	8,7	0,4	0,0	19,8	119	Yes	Yes	Yes	2	Yes	Yes	No
64	NF	810	18,5	8,7	0,0	13,6	49	Yes	No	No	3	Yes	Yes	No
65	NF	811	7,8	0,5	0,0	20,2	117	Yes	Yes	Yes	2	Yes	Yes	No
66	NF	812	17,1	11,4	0,0	13,4	49	Yes	No	No	3	Yes	Yes	No
67	NF	813	7,4	0,5	0,0	20,0	115	Yes	Yes	Yes	2	Yes	Yes	No
68	NF	814	20,3	11,5	0,0	11,4	49	Yes	No	No	3	Yes	Yes	No
69	NF	815	7,9	0,8	0,0	22,3	113	Yes	Yes	Yes	2	Yes	Yes	No
70	NF	816	23,7	6,9	0,0	9,5	49	Yes	No	No	3	Yes	Yes	No
71	NF	817	x	X	x	x	49	X	X	X	x	x	x	x
72	NF	833	x	X	x	x	49	X	X	X	x	x	x	x
73	NF	835	36,3	5,0	0,0	12,0	25	Yes	No	No	3	Yes	Yes	No
74	NF	903	16,2	1,5	0,0	21,4	25	Yes	Yes	Yes	3	Yes	Yes	No
75	NF	906	35,6	5,6	0,0	11,7	25	Yes	No	No	3	Yes	Yes	No
76	NF	917	24,7	0,6	2,0	19,7	39	Yes	Yes	Yes	3	Yes	Yes	Yes
77	NF	935	x	X	x	x	38	X	X	X	x	x	x	x
78	NF	1117K	x	X	x	x	38	X	X	X	x	x	x	x
79	NG	1135	x	X	x	x	38	X	X	X	x	x	x	x
80	NG	801	x	X	x	x	38	X	X	X	x	x	x	x
81	NG	802	x	X	x	x	38	X	X	X	x	x	x	x
82	NG	803	x	X	x	x	38	X	X	X	x	x	x	x
83	NG	804	26,4	0,9	3,1	17,6	75	Yes	Yes	Yes	3	Yes	Yes	Yes
84	NG	805	x	X	x	x	78	X	X	X	x	x	x	x
85	NG	806	25,1	0,9	2,9	17,4	85	Yes	Yes	Yes	3	Yes	Yes	Yes
86	NG	807	x	X	0	x	86	X	X	x	x	x	x	x
87	NG	808	28,1	0,9	2,8	17,3	87	Yes	Yes	Yes	3	Yes	Yes	Yes
88	NG	809	10,6	9,9	0,0	19,9	98	Yes	Yes	Yes	3	Yes	Yes	No
89	NG	810	29,5	0,9	3,0	17,0	89	Yes	Yes	Yes	3	Yes	Yes	Yes

90	NG	811	12,9	12,0	0,0	18,1	98	Yes	Yes	Yes	3	Yes	Yes	No
91	NG	812	28,6	0,6	2,6	15,1	91	Yes	Yes	Yes	3	Yes	Yes	Yes
92	NG	813	15,9	14,9	0,0	15,7	98	Yes	Yes	Yes	3	Yes	Yes	No
93	NG	814	5,0	12,9	0,0	24,8	84	Yes	Yes	No	3	Yes	Yes	No
94	NG	818	4,9	18,6	0,0	25,4	81	Yes	Yes	Yes	3	Yes	Yes	No
95	NG	820	5,3	19,1	0,0	25,3	81	Yes	Yes	Yes	3	Yes	Yes	No
96	NG	822	5,2	19,1	0,0	25,8	81	Yes	Yes	Yes	3	Yes	Yes	No
97	NG	824	4,6	18,5	0,0	25,4	81	Yes	Yes	Yes	3	Yes	Yes	No
98	NG	826	6,1	15,3	0,0	25,1	81	Yes	Yes	Yes	3	Yes	Yes	No
99	NG	828	7,8	1,1	0,1	24,9	81	Yes	Yes	Yes	3	Yes	Yes	Yes
100	NG	832	x	X	x	x	81	X	X	X	x	x	x	x
101	NG	1113	x	X	x	x	81	X	X	x	x	x	x	x
102	RG	1114	16,5	3,6	1,5	25,9	62	Yes	Yes	Yes	3	Yes	Yes	Yes
103	RG	801	12,8	4,1	1,9	27,5	61	Yes	Yes	Yes	3	Yes	Yes	Yes
104	RG	803	13,1	3,3	1,4	27,6	60	Yes	Yes	Yes	3	Yes	Yes	Yes
105	RG	805	13,8	3,6	1,5	27,9	59	Yes	Yes	Yes	3	Yes	Yes	Yes
106	RG	807	14,6	2,8	1,3	27,8	58	Yes	Yes	Yes	3	Yes	Yes	Yes
107	RG	809	26,4	1,1	3,2	18,0	58	Yes	Yes	Yes	3	Yes	Yes	Yes
108	RG	810	14,4	3,0	1,4	27,4	58	Yes	Yes	Yes	3	Yes	Yes	Yes
109	RG	811	16,5	2,4	1,1	27,6	58	Yes	Yes	Yes	3	Yes	Yes	Yes
110	RG	813	x	X	x	x	58	X	X	X	x	x	x	x
111	RG	814	16,08	2,0	1,1	26,2	58	Yes	Yes	Yes	3	Yes	Yes	Yes
112	RG	815	x	X	x	x	58	X	X	x	x	x	x	x
113	RG	817	34,8	0,9	2,4	13,0	54	Yes	Yes	Yes	3	Yes	Yes	Yes
114	RG	818	14,8	1,1	0,8	22,8	53	Yes	Yes	Yes	3	Yes	Yes	Yes
115	RG	821	21,6	0,0	2,8	22,0	51	Yes	Yes	Yes	3	Yes	Yes	Yes
116	RG	822	17,3	1,4	0,6	24,2	52	Yes	Yes	Yes	3	Yes	Yes	Yes
117	RG	823	20,7	0,1	2,9	22,8	53	Yes	Yes	Yes	3	Yes	Yes	Yes
118	RG	824	21,2	0,1	2,7	22,2	53	Yes	Yes	Yes	3	Yes	Yes	Yes
119	RG	826	20,2	0,7	0,6	22,0	58	Yes	Yes	Yes	3	Yes	Yes	Yes
120	RG	827	18,1	0,1	2,6	22,3	52	Yes	Yes	Yes	3	Yes	Yes	Yes
121	RG	828	21,4	0,8	0,6	23,0	58	Yes	Yes	Yes	3	Yes	Yes	Yes

122	RG	829	20,6	0,0	2,5	22,3	51	Yes	Yes	Yes	3	Yes	Yes	Yes
123	RG	830	21,7	0,5	0,5	20,3	58	Yes	Yes	Yes	3	Yes	Yes	Yes
124	RG	831	10,0	0,1	1,3	17,0	50	Yes	Yes	Yes	3	Yes	Yes	Yes
125	RG	832	24,3	0,6	0,5	21,9	58	Yes	Yes	Yes	3	Yes	Yes	Yes
126	RG	833	19,8	0,0	2,0	22,2	49	Yes	Yes	Yes	3	Yes	Yes	Yes
127	RG	834	14,8	1,1	0,9	22,8	49	Yes	Yes	Yes	3	Yes	Yes	Yes
128	RG	835	21,1	0,0	2,1	24,3	49	Yes	Yes	Yes	3	Yes	Yes	Yes
129	RG	836	x	X	x	x	49	X	X	x	x	x	x	x
130	RG	1103	x	X	x	x	49	X	x	x	x	x	x	x
131	RG	1106	x	X	x	x	49	X	X	x	x	x	x	x
132	RG	1118	x	X	x	x	49	X	x	x	x	x	x	x

Daylight parameter overall data set

ID	building_part	room	Ratio_illuminance	luminance
1	Nc	829	0,0638651	996,8
2	Nc	831	0,0552454	872,5
3	Nc	833	0,0570486	908,1
4	Nc	839	0,0525109	824,3
5	Nc	841	0,0744663	1160
6	Nc	843	0,086633	1395
7	Nc	923	0,0580882	884
8	Nc	830K	0,0328143	521,4
9	Nc	832K	0,0235011	371,6
10	Nc	834K	0,0218762	327
11	Nc	840K	0,0219753	334,4
12	Nc	842K	0,0272858	427
13	Nc	844K	0,0503113	847
14	Nc	846K	0,0930221	1121
15	Nc	848K	0,0772668	925,1
16	Nc	850K	0,0669477	788,9
17	Nc	942	0,0930221	495,5
18	Nd	836K	0,17866	1012
19	Nd	842K	0,1303279	727,2
20	Nd	844K	0,1772303	583,4
21	Nd	939	0,1498116	1132
22	Ne	801	0,0546985	217,5
23	Ne	803	0,0515497	207,2
24	Ne	805	0,0590168	240,1
25	Ne	807	0,0262298	231,7
26	Ne	809	0,0302684	253,8
27	Ne	811	0,0315012	280,9
28	Ne	813	0,0734111	324,3
29	Ne	815	0,0421292	390,7
30	Ne	901	0,0869397	886

31	Ne	903	0,0405918	3344,7
32	Ne	905	0,0725705	622,8
33	Ne	907	0,0809703	736,6
34	Ne	909	0,0898391	739,2
35	Ne	913	0,1236037	770,2
36	Ne	915	0,0781847	459,4
37	Nf	803	0,0215239	323,4
38	Nf	804	0,0191412	172,5
39	Nf	805	0,01748	259,7
40	Nf	806	0,0225441	195,2
41	Nf	807	0,024759	342,1
42	Nf	809	0,0208978	326,3
43	Nf	810	0,0397003	353
44	Nf	811	0,0206108	240,3
45	Nf	812	0,0198501	179,8
46	Nf	813	0,0156799	220,8
47	Nf	814	0,0246709	216,3
48	Nf	815	0,0163582	218,4
49	Nf	816	0,0223314	220,8
50	Nf	817	0,0131231	172,4
51	Nf	903	0,0429174	
52	Nf	906	0,0303422	
53	Nf	917	0,031151	
54	Nf	935	0,0385604	
55	Ng	805	0,0592919	827,7
56	Ng	807	0,0772126	1150
57	Ng	809	0,1410654	2292
58	Ng	810	0,1509459	2038
59	Ng	811	0,1200771	1858
60	Ng	812	0,1264319	2230
61	Ng	813	0,089967	1354
62	Ng	814	0,1437537	1844

63	Ng	818	0,0311227	502,1
64	Ng	820	0,0298835	484,3
65	Ng	822	0,0282107	458,5
66	Ng	824	0,0268477	434,2
67	Ng	826	0,030565	485,7
68	Ng	828	0,0303379	509,7
69	Ng	832	0,0306477	490,3
70	Rg	801	0,1757001	2227
71	Rg	803	0,1786951	2393
72	Rg	805	0,1944505	2452
73	Rg	807	0,1916316	2421
74	Rg	809	0,1900209	2365
75	Rg	811	0,1575537	2185
76	Rg	813	0,0655239	
77	Rg	815	0,1016511	1689
78	Rg	821	0,0877859	
79	Rg	823	0,0920959	
80	Rg	827	0,1144591	1763
81	Rg	829	0,1434906	2176
82	Rg	831	0,1445478	2186
83	Rg	833	0,0970842	1711
84	Rg	835	0,1362124	
85	Rg	810	0,0342793	4864
86	Rg	818	0,07551	1274
87	Rg	822	0,1496599	2529
88	Rg	824	0,0849371	
89	Rg	826	0,1142617	2036
90	Rg	828	0,1013134	1778
91	Rg	830	0,0902841	1621
92	Rg	832	0,1270237	2181
93	Rg	834	0,1124359	1953
94	Rg	836	0,1569086	2450

Appendix survey rooms analyzed on view factors and daylight parameters

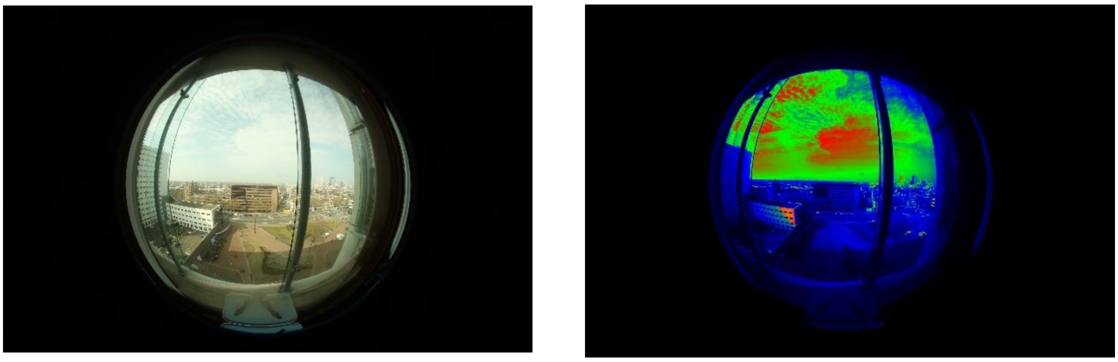

Figure 50 Rg-N 801

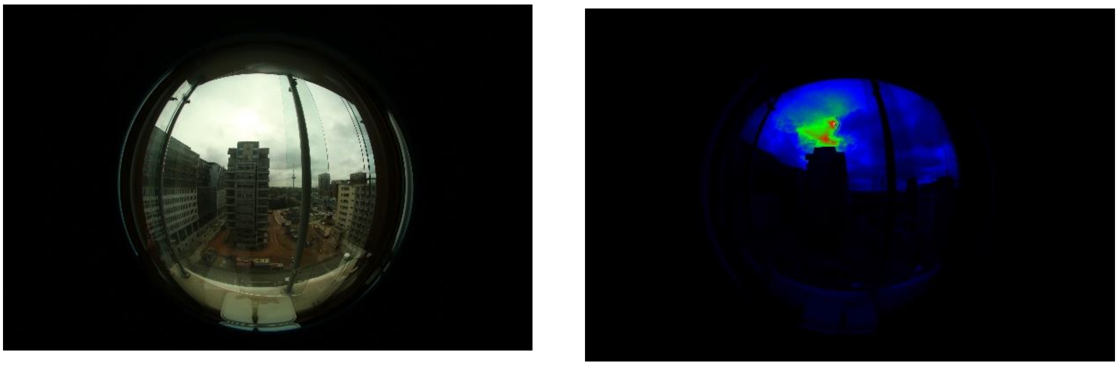

Figure 51 Rg-S 822

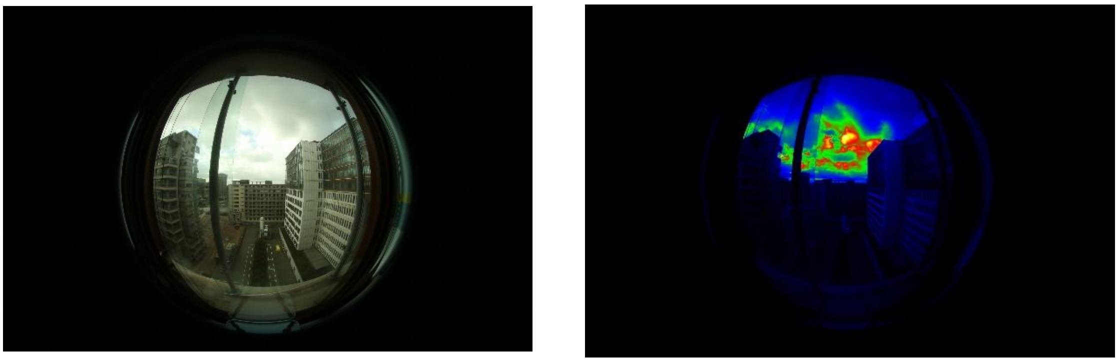

Figure 52 Ng805

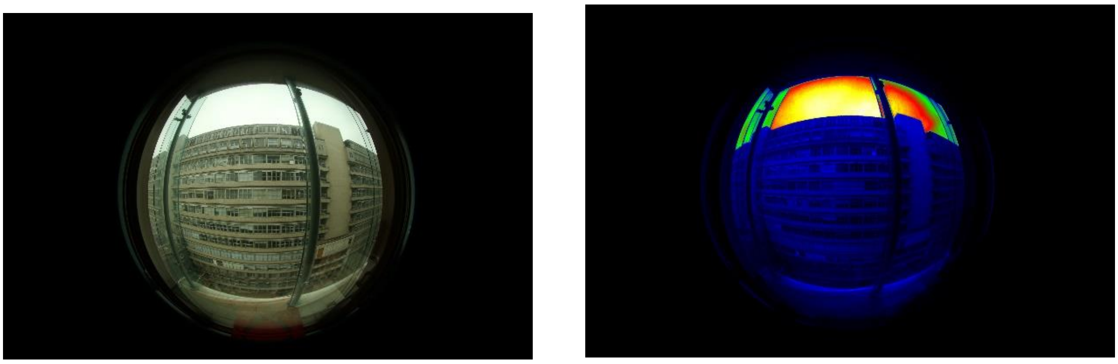

Figure 53 Ne801

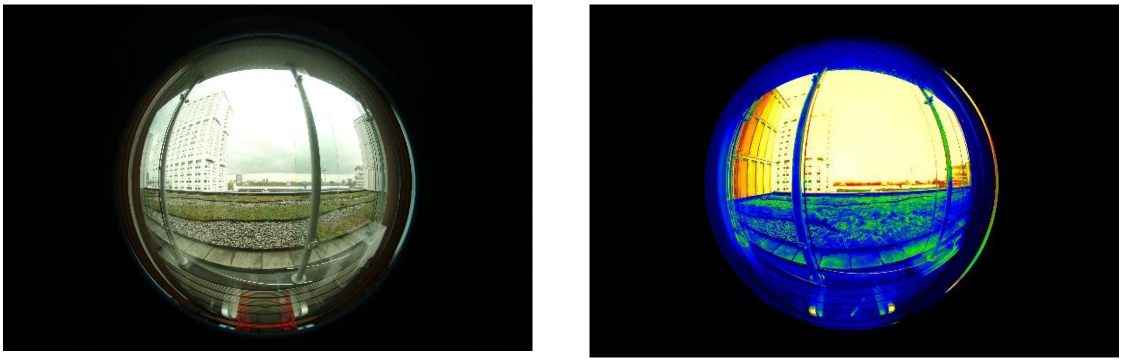

Figure 54 Nc-S 834

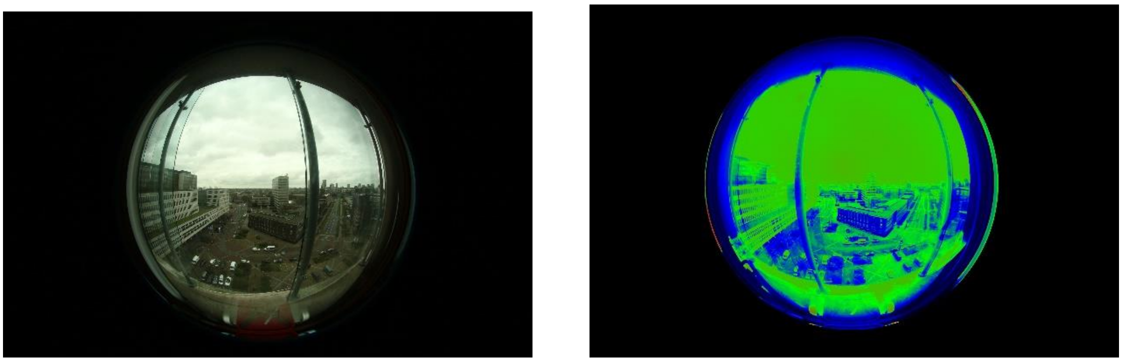

Figure 55 Nc-N 831

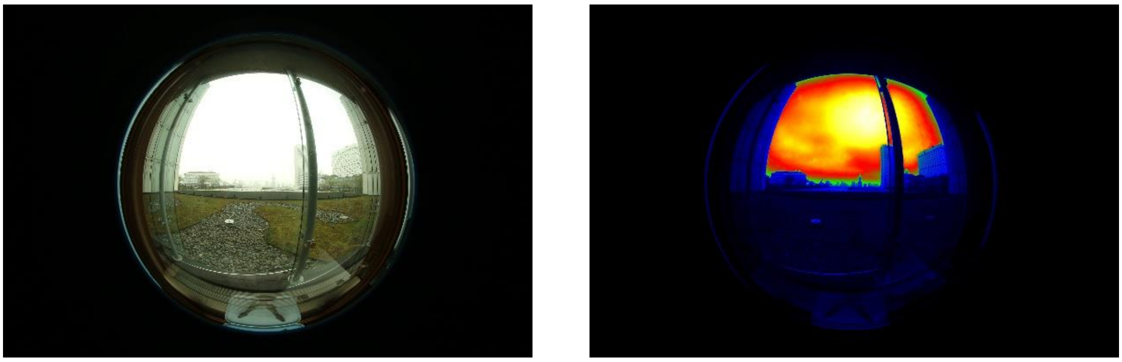

Figure 56 Ng808

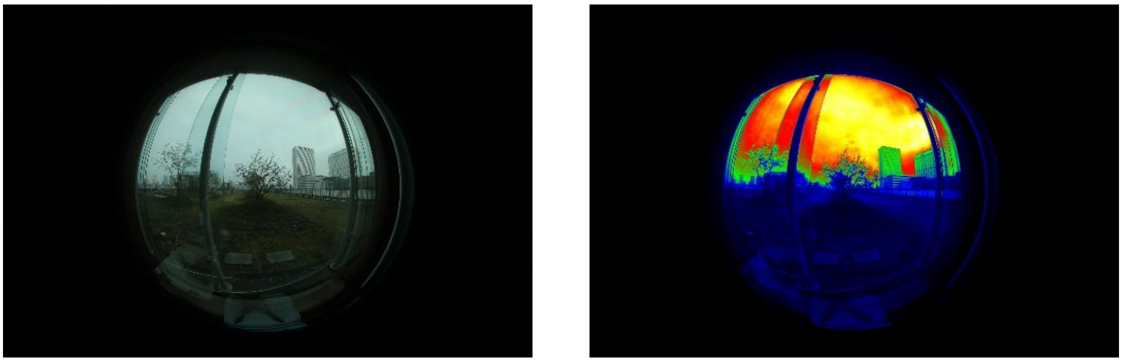

Figure 57 Ng822

Appendix conducted survey

hospital patient window view

Dear Madam, dear Sir,
We are a joint research team from the Technical University in Delft (TU Delft) and the Erasmus MC. We are conducting research on the effect of the visual environment on hospital patients. For this research we would like to find out what visual factors influence peoples' perception of a window view regarding interest and pleasantness.
The survey consist of 8 videos taken from window views in the hospital rooms of Erasmus MC. As participant in this survey, you are asked to rate each individual window view on pleasantness and on interest. The anonymized results of the survey are used to analyse peoples' perception of window views, to get a better understanding of peoples' perception of each individual view factor.
The survey is approved by the Human Research Ethics Committee (HREC), and the data collected from this survey will be processed and stored anonymously.
As participant in this survey, you could choose to partake in the raffle to win one of the prices.

Would you like to participate in the study and start the survey?
If you indicate below that you wish to participate in the study, you consent to collecting, storing and reviewing of the data you provided

- ◯ Yes, I would like to participate in the survey. (1)
- ◯ No, I would not like to participate in the survey. (2)
- ◯ I would love to have more information before I answer. (3)

In case the participant answered 1 the survey continued, answered 3 the survey ended for them and answered 2 the participant was shown the following information :

Participating in this study is voluntary. As participant you are always able to pause the survey and fill it in further at a later point in time. You are free to stop the survey at any point. You would not need to give a reasoning but we would like to use the answers you have given up until that point for the research. Your personal data and answers stay confidential and cannot be traced back to you personally. If you have questions at a later point about the confidentiality or results of the survey, you can contact us via email, Randy Bongers (r.r.m.r.bongers@student.tudelft.nl) , Dr. Clarine van Oel(c.j.vanoel@tudelft.nl) and Dr. Eleonora Brembilla (E.Brembilla@tudelft.nl).

Would you like to participate in the study and start the survey?
If you indicate below that you wish to participate in the study, you consent to us collecting, storing and reviewing the data you provided

- ◯ Yes, I would like to participate in the survey. (1)
- ◯ No, I would not like to participate in the survey. (2)

What is your gender?

- ◯ Male (1)
- ◯ Female (2)
- ◯ Non-binary (3)
- ◯ Prefer not to say (4)

Q41 What is your age

____

Q4 I understood the information given in the survey introduction.

- ◯ Yes (1)
- ◯ No (2)

Q5 I declare that my participation is voluntarily.

- ◯ Yes (1)
- ◯ No (2)

Q6 I understand that the data will be stored and processed anonymously.

- ◯ Yes (1)
- ◯ No (2)

Q7 I give permission for the collected data to be used in further research.

- ◯ Yes (1)
- ◯ No (2)

Q9 In the following videos, the window view from 8 different locations in the hospital is shown. Please rate each window view on pleasantness and interest, where 0 is unpleasant/ uninteresting and 10 is pleasant/ interesting. In the first 25 seconds of each video, you will see the view out of the window, moving from [left to right and back]. After these 25 seconds the video shows a static view. Please watch the first part in its entirety and then feel free to stop the videos when you gained a sufficient impression of the view seen from the window.

The rate scale for interest and pleasantness are shown below, these scales are used for all the 8 of the videos.

Q1.1 On a scale from 1-10, how pleasant do you think the view is?

- ○ 0 (0)
- ○ 1 (1)
- ○ 2 (2)
- ○ 3 (3)
- ○ 4 (4)
- ○ 5 (5)
- ○ 6 (6)
- ○ 7 (7)
- ○ 8 (8)
- ○ 9 (9)
- ○ 10 (10)

Q1.2 On a scale from 1-10, how interesting do you think the view is?

- 0 (0)
- 1 (1)
- 2 (2)
- 3 (3)
- 4 (4)
- 5 (5)
- 6 (6)
- 7 (7)
- 8 (8)
- 9 (9)
- 10 (10)

Figure 58 View direction Ng808

Figure 59 View direction Rg801

Figure 60 View direction Rg822

Figure 61 View direction Ng805

Figure 62 View direction Ng822

Figure 63 View direction Ne801

Figure 64 View direction Nc831

Figure 65 View direction Nc834

Q8 What was the device you completed the survey on ?

- Laptop (1)
- Tablet (2)
- Phone (3)

Q9 During what part of the day did you complete the survey in ?

- Morning (1)
- Afternoon (2)
- Evening (3)

Q10 Do you work in the healthcare?

- Yes (1)
- No (4)

Q11 Do you have any comments regarding the survey?

____

Q12 If you would like to participate in the raffle to win one of the prices, please leave your email address in the text bar below.

____

Appendix NEN-EN 17037 based pictures















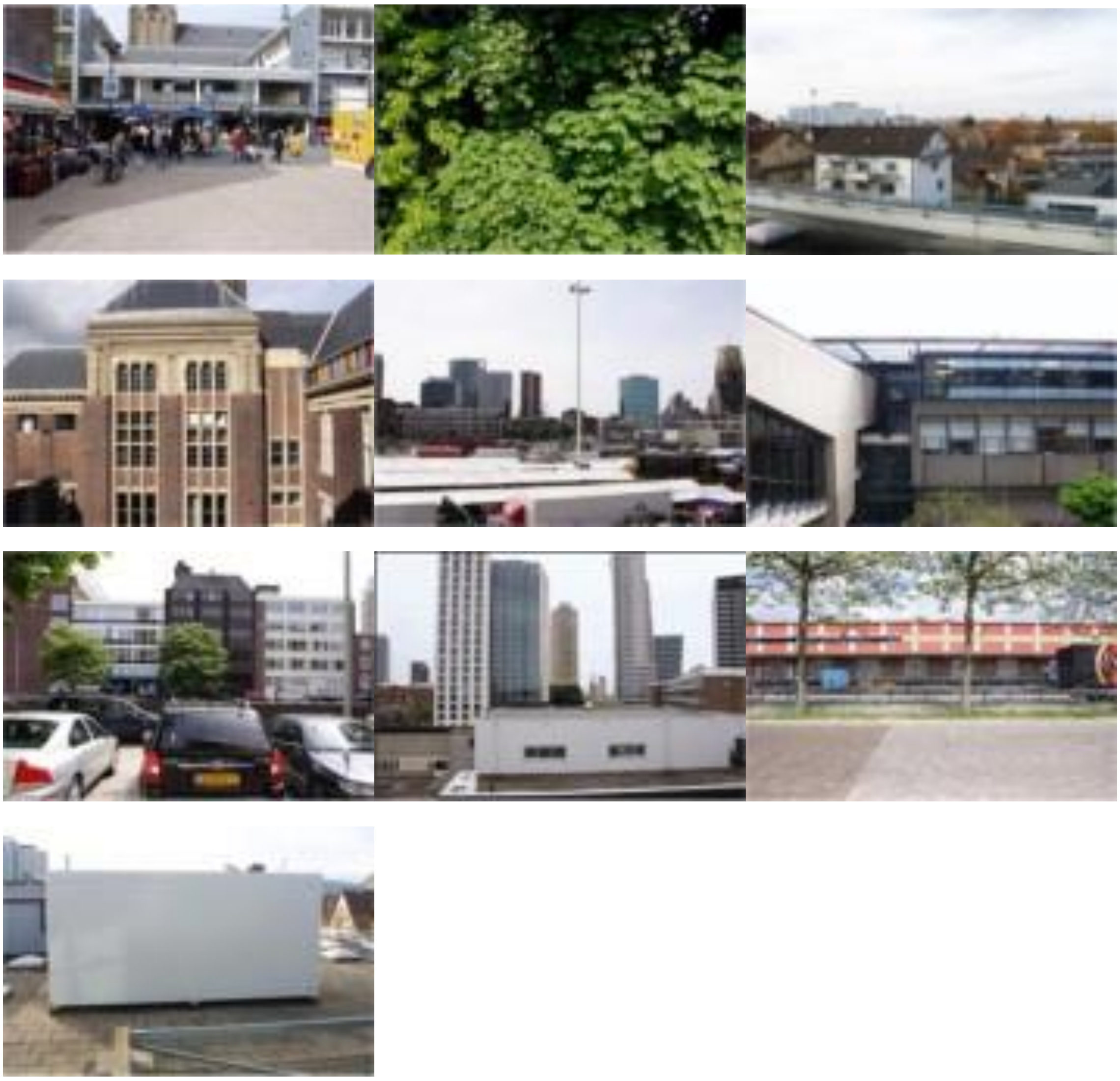

Appendix correlation between view factors and daylight parameter for each view direction

For each view direction the significance of the correlation between the view factor and daylight parameters were different, however the number of rooms per view direction were different as well. Which could have as result that some values were heighted and other values were averaged out. Therefore it would be recommended to reproduced the analysis with higher and equal room numbers per view direction.

Nc north

Correlations

				luminance	Ratio_illuminance
building_ratio	Pearson Correlation			.501	.472
	Sig. (2-tailed)			.252	.285
	N			7	7
	Bootstrap[c]	Bias		-.016	-.024
		Std. Error		.413	.428
		95% Confidence Interval	Lower	-.508	-.584
			Upper	.984	.988
greenery_ratio	Pearson Correlation			.611	.567
	Sig. (2-tailed)			.145	.185
	N			7	7
	Bootstrap[c]	Bias		-.012	-.025
		Std. Error		.304	.352
		95% Confidence Interval	Lower	-.296	-.512
			Upper	.964	.961
streets _water _ratio	Pearson Correlation			-.853*	-.852*
	Sig. (2-tailed)			.015	.015
	N			7	7
	Bootstrap[c]	Bias		-.012	.018
		Std. Error		.131	.217
		95% Confidence Interval	Lower	-.994	-.993
			Upper	-.466	-.127
sky_ratio	Pearson Correlation			-.313	-.358
	Sig. (2-tailed)			.495	.431
	N			7	7
	Bootstrap[c]	Bias		.031	.012
		Std. Error		.373	.326
		95% Confidence Interval	Lower	-.931	-.933
			Upper	.446	.308

*. Correlation is significant at the 0.05 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Nc south

Correlations

					luminance	Ratio_illuminance
building_ratio	Pearson Correlation				.137	-.189
	Sig. (2-tailed)				.706	.602
	N				10	10
	Bootstrap[d]	Bias			.036	.052
		Std. Error			.235	.331
		95% Confidence Interval	Lower		-.288	-.668
			Upper		.603	.594
greenery_ratio	Pearson Correlation				.508	.106
	Sig. (2-tailed)				.134	.772
	N				10	10
	Bootstrap[d]	Bias			-.020	.060
		Std. Error			.280	.465
		95% Confidence Interval	Lower		-.213	-.814
			Upper		.864	.925
streets _water _ratio	Pearson Correlation				.[a]	.[a]
	Sig. (2-tailed)				.	.
	N				10	10
	Bootstrap[d]	Bias			.[e]	.[e]
		Std. Error			.[e]	.[e]
		95% Confidence Interval	Lower		.[e,f]	.[e,f]
			Upper		.[e,f]	.[e,f]
sky_ratio	Pearson Correlation				.147	-.497
	Sig. (2-tailed)				.685	.144
	N				10	10
	Bootstrap[d]	Bias			-.051	.065
		Std. Error			.251	.342
		95% Confidence Interval	Lower		-.512	-.932
			Upper		.533	.381

a. Cannot be computed because at least one of the variables is constant.

d. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

e. Based on 0 samples

f. A 95% confidence interval requires at least 39 bootstrap samples.

Nd

Correlations

					luminance	Ratio_illuminance
building_ratio	Pearson Correlation				-.943	.305
	Sig. (2-tailed)				.057	.695
	N				4	4
	Bootstrap[d]	Bias			-.027[e]	-.113[e]
		Std. Error			.038[e]	.674[e]
		95% Confidence Interval	Lower		-1.000[e]	-1.000[e]
			Upper		-.880[e]	1.000[e]
greenery_ratio	Pearson Correlation				-.283	-.080
	Sig. (2-tailed)				.717	.920
	N				4	4
	Bootstrap[d]	Bias			.063[e]	.046[e]
		Std. Error			.707[e]	.715[e]
		95% Confidence Interval	Lower		-1.000[e]	-1.000[e]
			Upper		1.000[e]	1.000[e]
streets _water _ratio	Pearson Correlation				.[a]	.[a]
	Sig. (2-tailed)				.	.
	N				4	4
	Bootstrap[d]	Bias			.[f]	.[f]
		Std. Error			.[f]	.[f]
		95% Confidence Interval	Lower		.[f,g]	.[f,g]
			Upper		.[f,g]	.[f,g]
sky_ratio	Pearson Correlation				.914	-.387
	Sig. (2-tailed)				.086	.613
	N				4	4
	Bootstrap[d]	Bias			.018[e]	.090[e]
		Std. Error			.078[e]	.642[e]
		95% Confidence Interval	Lower		.725[e]	-1.000[e]
			Upper		1.000[e]	1.000[e]

a. Cannot be computed because at least one of the variables is constant.

d. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

e. Based on 983 samples

f. Based on 0 samples

g. A 95% confidence interval requires at least 39 bootstrap samples.

Ne

Correlations

				luminance	Ratio_illuminance
building_ratio	Pearson Correlation			.244	-.024
	Sig. (2-tailed)			.380	.933
	N			15	15
	Bootstrap[d]	Bias		-.020	-.028
		Std. Error		.195	.202
		95% Confidence Interval	Lower	-.340	-.556
			Upper	.518	.314
greenery_ratio	Pearson Correlation			.[a]	.[a]
	Sig. (2-tailed)			.	.
	N			15	15
	Bootstrap[d]	Bias		.[e]	.[e]
		Std. Error		.[e]	.[e]
		95% Confidence Interval	Lower	.[e,f]	.[e,f]
			Upper	.[e,f]	.[e,f]
streets _water _ratio	Pearson Correlation			.[a]	.[a]
	Sig. (2-tailed)			.	.
	N			15	15
	Bootstrap[d]	Bias		.[e]	.[e]
		Std. Error		.[e]	.[e]
		95% Confidence Interval	Lower	.[e,f]	.[e,f]
			Upper	.[e,f]	.[e,f]
sky_ratio	Pearson Correlation			.606*	.560*
	Sig. (2-tailed)			.017	.030
	N			15	15
	Bootstrap[d]	Bias		.103	.000
		Std. Error		.108	.191
		95% Confidence Interval	Lower	.555	.152
			Upper	.909	.891

*. Correlation is significant at the 0.05 level (2-tailed).

a. Cannot be computed because at least one of the variables is constant.

d. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

e. Based on 0 samples

f. A 95% confidence interval requires at least 39 bootstrap samples.

Nf

Correlations

					luminance	Ratio_illuminance
building_ratio	Pearson Correlation				.136	-.551*
	Sig. (2-tailed)				.643	.041
	N				14	14
	Bootstrap[d]	Bias			.025	.000
		Std. Error			.286	.153
		95% Confidence Interval	Lower		-.431	-.813
			Upper		.671	-.209
greenery_ratio	Pearson Correlation				.310	-.442
	Sig. (2-tailed)				.281	.114
	N				14	14
	Bootstrap[d]	Bias			.012	-.002
		Std. Error			.257	.185
		95% Confidence Interval	Lower		-.213	-.749
			Upper		.758	-.009
streets _water _ratio	Pearson Correlation				.[b]	.[b]
	Sig. (2-tailed)				.	.
	N				14	14
	Bootstrap[d]	Bias			.[e]	.[e]
		Std. Error			.[e]	.[e]
		95% Confidence Interval	Lower		.[e,f]	.[e,f]
			Upper		.[e,f]	.[e,f]
sky_ratio	Pearson Correlation				-.167	.535*
	Sig. (2-tailed)				.568	.049
	N				14	14
	Bootstrap[d]	Bias			-.026	.005
		Std. Error			.274	.149
		95% Confidence Interval	Lower		-.667	.219
			Upper		.373	.806

*. Correlation is significant at the 0.05 level (2-tailed).

b. Cannot be computed because at least one of the variables is constant.

d. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

e. Based on 0 samples

f. A 95% confidence interval requires at least 39 bootstrap samples.

Ng

Correlations

					luminance	Ratio_illumina nce
building_ratio	Pearson Correlation				.603*	.593*
	Sig. (2-tailed)				.017	.020
	N				15	15
	Bootstrap[c]	Bias			.004	.006
		Std. Error			.159	.162
		95% Confidence Interval	Lower		.243	.250
			Upper		.890	.901
greenery_ratio	Pearson Correlation				-.420	-.402
	Sig. (2-tailed)				.119	.138
	N				15	15
	Bootstrap[c]	Bias			.005	.004
		Std. Error			.211	.218
		95% Confidence Interval	Lower		-.769	-.755
			Upper		.036	.061
streets _water _ratio	Pearson Correlation				.351	.328
	Sig. (2-tailed)				.200	.233
	N				15	15
	Bootstrap[c]	Bias			.006	.009
		Std. Error			.225	.229
		95% Confidence Interval	Lower		-.101	-.083
			Upper		.823	.862
sky_ratio	Pearson Correlation				-.799**	-.817**
	Sig. (2-tailed)				<,001	<,001
	N				15	15
	Bootstrap[c]	Bias			-.005	-.004
		Std. Error			.084	.087
		95% Confidence Interval	Lower		-.946	-.955
			Upper		-.622	-.625

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Rg North

Correlations

					luminance	Ratio_illuminance
building_ratio	Pearson Correlation				-.642*	-.737**
	Sig. (2-tailed)				.033	.010
	N				11	11
	Bootstrap[c]	Bias			.007	.010
		Std. Error			.207	.165
		95% Confidence Interval	Lower		-.948	-.958
			Upper		-.166	-.358
greenery_ratio	Pearson Correlation				.675*	.772**
	Sig. (2-tailed)				.023	.005
	N				11	11
	Bootstrap[c]	Bias			.000	.002
		Std. Error			.157	.110
		95% Confidence Interval	Lower		.321	.549
			Upper		.924	.928
streets _water _ratio	Pearson Correlation				.645*	.733*
	Sig. (2-tailed)				.032	.010
	N				11	11
	Bootstrap[c]	Bias			.000	.004
		Std. Error			.165	.121
		95% Confidence Interval	Lower		.275	.487
			Upper		.902	.909
sky_ratio	Pearson Correlation				.569	.678*
	Sig. (2-tailed)				.068	.022
	N				11	11
	Bootstrap[c]	Bias			.012	.008
		Std. Error			.227	.180
		95% Confidence Interval	Lower		.094	.294
			Upper		.951	.964

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Rg south

Correlations

					luminance	Ratio_illuminance
building_ratio	Pearson Correlation				.057	-.498
	Sig. (2-tailed)				.883	.173
	N				9	9
	Bootstrap[c]	Bias			-.052	.005
		Std. Error			.510	.262
		95% Confidence Interval	Lower		-.851	-.856
			Upper		.961	.310
greenery_ratio	Pearson Correlation				.505	-.811**
	Sig. (2-tailed)				.165	.008
	N				9	9
	Bootstrap[c]	Bias			-.306	.060
		Std. Error			.675	.234
		95% Confidence Interval	Lower		-.905	-.959
			Upper		.986	-.063
streets _water _ratio	Pearson Correlation				.452	-.476
	Sig. (2-tailed)				.222	.195
	N				9	9
	Bootstrap[c]	Bias			-.140	.034
		Std. Error			.429	.297
		95% Confidence Interval	Lower		-.612	-.888
			Upper		.923	.197
sky_ratio	Pearson Correlation				-.024	.533
	Sig. (2-tailed)				.952	.139
	N				9	9
	Bootstrap[c]	Bias			.060	-.012
		Std. Error			.491	.271
		95% Confidence Interval	Lower		-.919	-.123
			Upper		.865	.937

**. Correlation is significant at the 0.01 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples