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THE IMPACT OF SUN HOUR AND SKY VIEW FACTOR ON HOSPITAL BUILDINGS DESIGN: A PARAMETRIC DESIGN ANALYSIS IN KONYA, TURKEY

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Abstract

During the initial phases of hospital design, consideration of parameters such as sun hour and sky view factor can profoundly impact the well-being of patients and healthcare personnel. This study examines the use of parametric design techniques, facilitated by Rhino and the Grasshopper plugin, to create an algorithm for evaluating the effects of sun hour and sky view factor parameters on the health and well-being of patients and healthcare personnel. The algorithm aims to analyze the impact of solar hours and sky view factor parameters on the design of hospital buildings in Konya, Turkey. For this purpose, Numune Hospital, City Hospital, and Selçuk University Faculty of Medicine Hospital in Konya were selected for analysis. The identified hospital buildings and their built environments were modelled to scale for analysis. The study found that sun hour and sky view factor levels were higher in outward-facing blocks of the examined hospitals, while they were lower in lower-rise blocks that were closer together. The research suggests that taking into account sun hour and sky view factor parameters during the design of hospital buildings can assist designers in making informed decisions at both urban and architectural scales.

Keywords: Hospital buildings, Parametric design method, Sky view factor, Sun hour.

1. Introduction

Hospital buildings play a crucial role in the healthcare system, and their design and construction can have a significant impact on the health and well-being of patients. An important aspect of hospital building design is the effect of sun hour and sky view factor on patients' health outcomes. Research has shown that views of daylight and natural elements can evoke positive emotions and contribute to relaxation in patients [1, 2]. Skylights are a physical aspect of hospital design that can provide a healing space and increase patient satisfaction [2-4].

Seyedahmadi indicated that adequate and appropriate exposure to sunlight can have a positive impact on the health and well-being of people in a hospital setting [5]. The factors that positively affect the satisfaction of patients can be related to the use of facilities such as well-decorated rooms and hotel facilities, where noise is reduced, natural light is increased, and visitor-friendly facilities are offered in the hospital design [6]. These factors contribute positively to satisfaction with doctor and nurse services, food service, cleaning services, and the hospital in general. Creating a healing space rather than a barrier to healing is the most challenging aspect of hospital design [7]. In buildings designed with a focus on human health, factors such as sunbathing and sky vision factor must be considered in the designs.

The design and construction of hospital buildings are critical to ensuring the health and well-being of patients, staff, and visitors. Various factors are considered when designing and evaluating hospital buildings, including their orientation to the sun, the amount of natural light they receive, and sky views. These factors can have a significant impact on the energy efficiency of the building as well as the well-being and comfort of patients. To increase the comfort performance of people, optimized designs can be developed by integrating the daylight factor into the architecture [8, 9]. However, while most research focuses on energy efficiency or a specific parameter, access to sunlight and sky view factor (SVF), which have a significant impact on patient's well-being and comfort, are often overlooked.

This study emphasizes the importance of architects integrating sun hour and SVF parameters into the design process of hospital buildings and connecting these parameters using the parametric design approach. The investigation was conducted in Konya, Turkey, and assessed three hospital buildings of different sizes: Konya Numune Hospital, Konya City Hospital, and Konya Selçuk University Medical Faculty Hospital. The selection of these hospitals was based on their positions and densities within the city's radial growth model. The objective of the study is to examine the influence of solar hour and SVF parameters on the chosen samples in Konya and their impact on the well-being and health of patients and healthcare personnel. To attain this objective, the morphological structure of the city and the characteristics of hospital buildings were analysed through mass simplification. This approach provides a means to calculate SVF footprints and annual sunlight exposure. It can assist architects in making informed decisions when designing hospital buildings at both urban and architectural scales.

2. Literature Review

Sun hour is a measure used to determine the amount of sunlight to understand the duration and intensity of sunlight in different regions [10]. The analysis conducted using sun hour yields results based on a standard sensor grid, typically a 1x1m grid

[11]. The surfaces under examination are categorized into different groups according to their exposure levels to the sun, as depicted in Fig. 1(a). On the other hand, SVF is a parameter used in urban planning, architectural and environmental modelling to measure the proportion of visible sky view from a specific location or point in a given area [12]. Calculating SVF entails considering the heights and positions of surrounding buildings. Typically, a comprehensive 360-degree evaluation of the field of view is conducted to ascertain the ratio of surface area facing the sky, while factoring in obstacles and variations in elevation (Fig. 1(b)). The SVF value is determined using a predefined relationship. The equation, as shown in Eq. (1) [13], utilizes 'm' to represent the number of annuli, 'i' to denote the annulus index, and 'αi' to represent the angular width of the ith annulus in the calculation of SVF.

$$SVF = \frac{1}{2m}\sin\left(\frac{\pi}{2m}\right)\sum_{i=1}^{m}\sin\left(\frac{\pi(2i-1)}{2m}\right)a_i \quad (1)$$

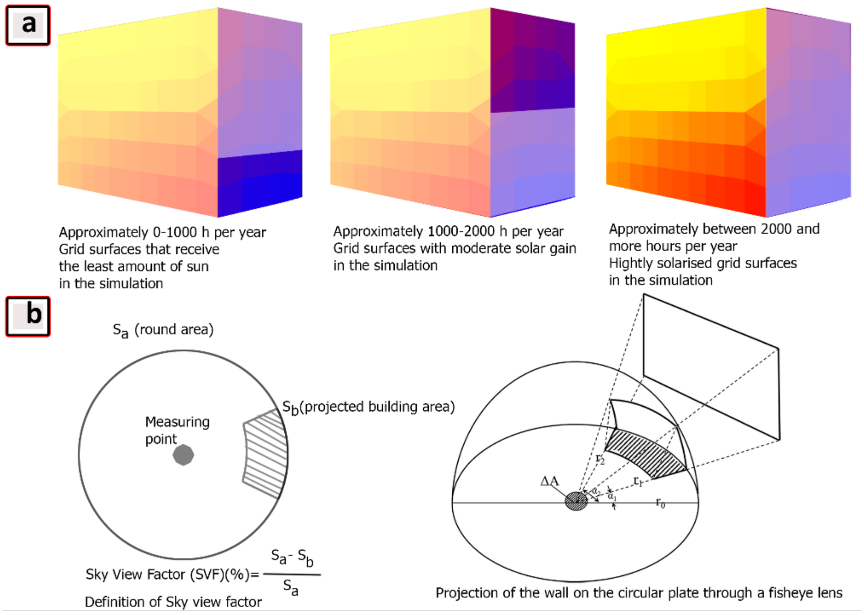

Fig. 1. Sun hour and SVF factors calculations; (a) grid surfaces (this study), (b) SVF calculation [13].

In recent years, both sun hour and SVF parameters have been studied independently. When the researches made specifically for sun hour are examined; Kim et al. [14] stated in their study that a design tool could be developed that aims to suggest the mass that can meet the standard of two consecutive sunlight hours at the winter solstice, through an algorithm based on environmental simulations. Suk-Jin and Seong-Hwan [15] investigated the effect of building coverage ratio and floor area ratio on sunlight environment and outdoor thermal environment in multi-family residential complexes for a comfortable residential atmosphere and environmental sustainability. Canan [16] and Luca and Voll [17] introduced a methodology that produces solar envelopes to efficiently capture insolation, concurrently accounting for sunlight prerequisites and local circumstances within various urban contexts. Lu and Du [18] conducted an analysis utilizing Radiance and Autodesk Ecotect to ascertain the correlations among sunlight duration, building orientations, and layouts. This was accomplished through the computation of vertical daylight factors and sun hours along the building facade.

When examining research on SVF, Chatzipoulka et al. [19] investigated the potential of SVF measurement in evaluating the solar exposure of facades within intricate urban environments. Miao et al. [12] described big data approaches using geometric methods, fisheye photography methods, GPS-based methods, simulation methods based on 3D city models or digital surface models, and street view images used to calculate SVF. In addition, the research highlighted the principles, input data, applications, accuracy and efficiency of each method. Silva et al. [20] showed an inverse relationship between noise levels and SVF by calculating traffic noise levels and SVF in regions with different urban geometries. Kakon and Nobuo [21] obtained SVF and radiation values in the city centre with high-rise buildings and narrow roads to investigate the effect of SVF on the microclimate in different seasons. As a result of these values, he stated that there is a direct proportional relationship between solar radiation and SVF.

This article investigates the significance of sun hours and SVF in hospital building design through a parametric approach. Architects can incorporate sun hour and SVF parameters into their designs for hospital buildings using this method. Furthermore, this approach enables the creation of designs that manipulate the interaction between design parameters using algorithms and rules.

3. The Study Area

Turkey stands out as a country situated at the crossroads of Asia and Europe, boasting a rich cultural heritage intertwined with a deep and diverse history. Located in the Central Anatolia Region of Turkey, Konya is a city of significant historical and cultural importance. Particularly renowned for being the final resting place of Mevlana Celaleddin Rumi, Konya has emerged throughout history as a pivotal historical centre radiating from the focal points of Alaaddin Tepesi, Mevlana, and the Bedesten District. Despite exhibiting radial growth and development in the northeast direction, the city still maintains a growth pattern that emanates from its centre. This radial growth pattern significantly influences the positioning of hospital buildings.

Konya Numune Hospital is situated in a region close to the centre of this radial development. Continuing the radial growth towards the northeast, Konya City Hospital is located, while Konya Selçuk University Faculty of Medicine Hospital lies on the periphery of this direction. All three hospitals have high user capacity and density. The Konya Numune Hospital, completed in 2018, accommodates 610 beds and includes various facilities such as parking for 1,300 vehicles, intensive care units, outpatient clinics, and operating theatres. Meanwhile, the Konya City Hospital, spread over 616,000 square meters with 412,187 square meters indoors, features 1250 beds, 330 outpatient clinic rooms, 266 intensive care units, 14 maternity units, 48 operating theatres, a 15-bed burn unit, along with offices, parking for 1250 vehicles, and a heliport. The Konya Selçuk University Faculty of Medicine Hospital, with an indoor area of 130,000 square meters and an outdoor area of 160,000 square meters, hosts 963 beds and 22 operating theatres. Therefore, hospital buildings such as Konya Numune Hospital, Konya City Hospital, and

Selçuk University Faculty of Medicine Hospital were selected as case studies and analyzed in Konya. Figure 2 illustrates the locations of the analyzed hospital buildings throughout the city of Konya.

Fig. 2. Case study hospital buildings and historical focal points at Konya.

4. Materials and Methods

The research focuses on investigating the effect of sun hours and SVF parameters on the architectural layout of hospital structures in Konya, Turkey, and their impact on the well-being of patients and healthcare staff. The study aims to enhance the design of hospital buildings by modifying the interrelationships among design parameters and incorporating natural light, using parametric design analysis and algorithms available in Rhino and Grasshopper.

4.1. Rhinoceros and Grasshopper

Rhinoceros and Grasshopper are computer tools used in geometric modelling and design processes [22] (Fig. 3). Rhinoceros is a widely used three-dimensional CAD modeller that can establish connections with advanced daylight simulations using Radiance and Daysim [23]. An online data transfer web page (Ladybug, EPWMap) facilitates synchronization between Rhinoceros and the Grasshopper plugin [24]. This web page acquires climatic data relevant to Konya's geographical location on Earth. The data is then processed by algorithms generated within Grasshopper (Figs. 4(a) and (b)).

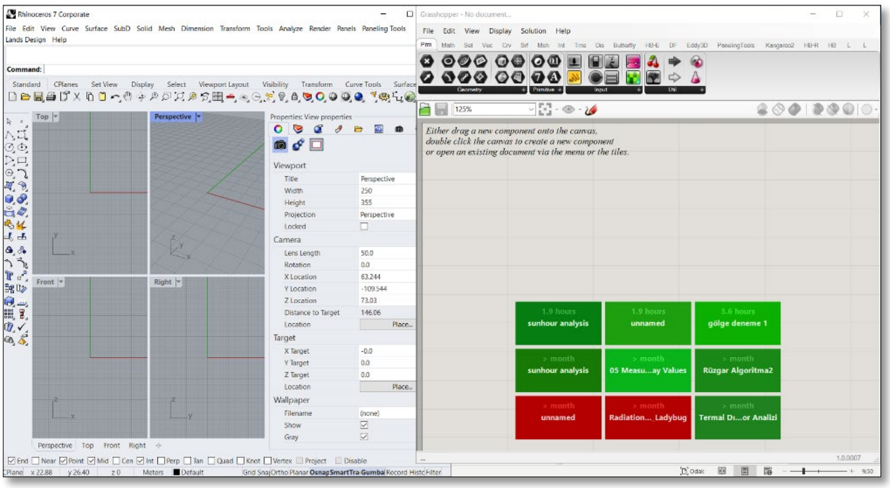

Fig. 3. The interface of the Rhinoceros and Grasshopper program.

4.2. Sun hour

Sun hour analysis calculates the hourly distribution of sunlight falling on surfaces. This analysis component processes the solar vectors it receives from the Epw file for a certain period and analyzes it considering the built environment that blocks the light intake rate. The maximum amount of direct sunlight can be analyzed by simulating the formal and geometrical structure in the formation of the built environment. Such a simulation calculates the average number of hours the sun's rays fall directly on the surface, and the final output unit is given as h/m2, which is the amount of light per hour. The study obtains data on climate parameters by determining Konya's geographical location on Earth through an online data transfer web page for conducting sun hour analysis. The Grasshopper interface processes this data using components such as importEPW, analysis period, sunpath, and DirectSunHours to generate algorithms (Fig. 4(a)).

The importEPW component is used to import EnergyPlus Weather files into Grasshopper for building energy performance analysis. The analysis period component conducts energy analysis over a specific time interval, considering variations in sunlight and weather conditions. The sunpath component aids in assessing solar exposure in building design by visualizing the solar path for a specified location and time range. Finally, the DirectSunHours component calculates the duration of direct sunlight exposure, which is crucial for activities that rely on sunlight. These calculations examine the sun hour analysis of hospital buildings to provide realistic results by determining whether hospital buildings receive sufficient and uniform sunlight exposure and by calculating the annual amount of natural light received.

4.3. Sky view factor (SVF)

Sky view factor (SVF) is a measure of the amount of sky visible from a given location on the ground. In the design of buildings, SVF affects the amount of sunlight and shade taken, depending on the obstacles created by the immediate environment. A high SVF value causes higher temperatures, while a low value causes a lack of natural light. The SVF value can be measured using a fisheye lens, a sky scanner, or by computer software method by determining the angle between the horizon and the visible sky at a specific location on the ground. SVF ranges from 0 to 1 and is expressed as a percentage [25]. An SVF value of 0 (0%) indicates the sky is completely blocked by buildings or other objects. An SVF value of 1 (100%) indicates an unobstructed clear sky without any buildings or other objects. The purpose of this study is to conduct SVF (Sky View Factor) analysis on hospital buildings and the surrounding urban fabric. Data on the dimensions of these buildings, including their length, width, and height, were obtained from municipal authorities.

The Grasshopper interface components ViewPercent and SyMask were used to process this data and generate algorithms (Fig. 4(b)). The ViewPercent component is used in Rhino 3D software to display a specific portion of an image and improve user focus. On the other hand, the SyMask component in Grasshopper conceals or modifies data within a particular region, making data more accessible to users. These components allow for precise manipulation and concentration on image areas or data sets, thereby enhancing productivity and efficiency in design and modelling tasks. Conducting calculations both on mass surfaces and at specific points while examining SVF analysis of hospital buildings will yield realistic results in determining whether adequate natural sunlight is being received, thus ensuring appropriate levels of productivity.

4.4. Parametric design method

The parametric design method is an innovative method that uses the relationships between parameters to give, organize and optimize the final design of complex geometries and structures. It uses a flexible set of algorithms and rules that can adjust relationships between parameters and provide fast returns. The Parametric Design Method involves the use of software tools such as Computer Aided Design (CAD) and Building Information Modeling (BIM) to create parametric models. These models are based on certain parameters or rules that define the design, such as the size, shape, and orientation of the different elements. By using software tools to define and adjust design parameters, designers can create efficient, optimized and visually stunning designs that meet the needs of the project. In this study, an algorithm was created in Grasshopper, an add-on of Rhino, considering the parameters of sun hour and SVF together and specific to these parameters. With this algorithm, the sun hour and SVF values of the existing hospital buildings will be calculated and evaluated (Figs. 4(a) and (b)).

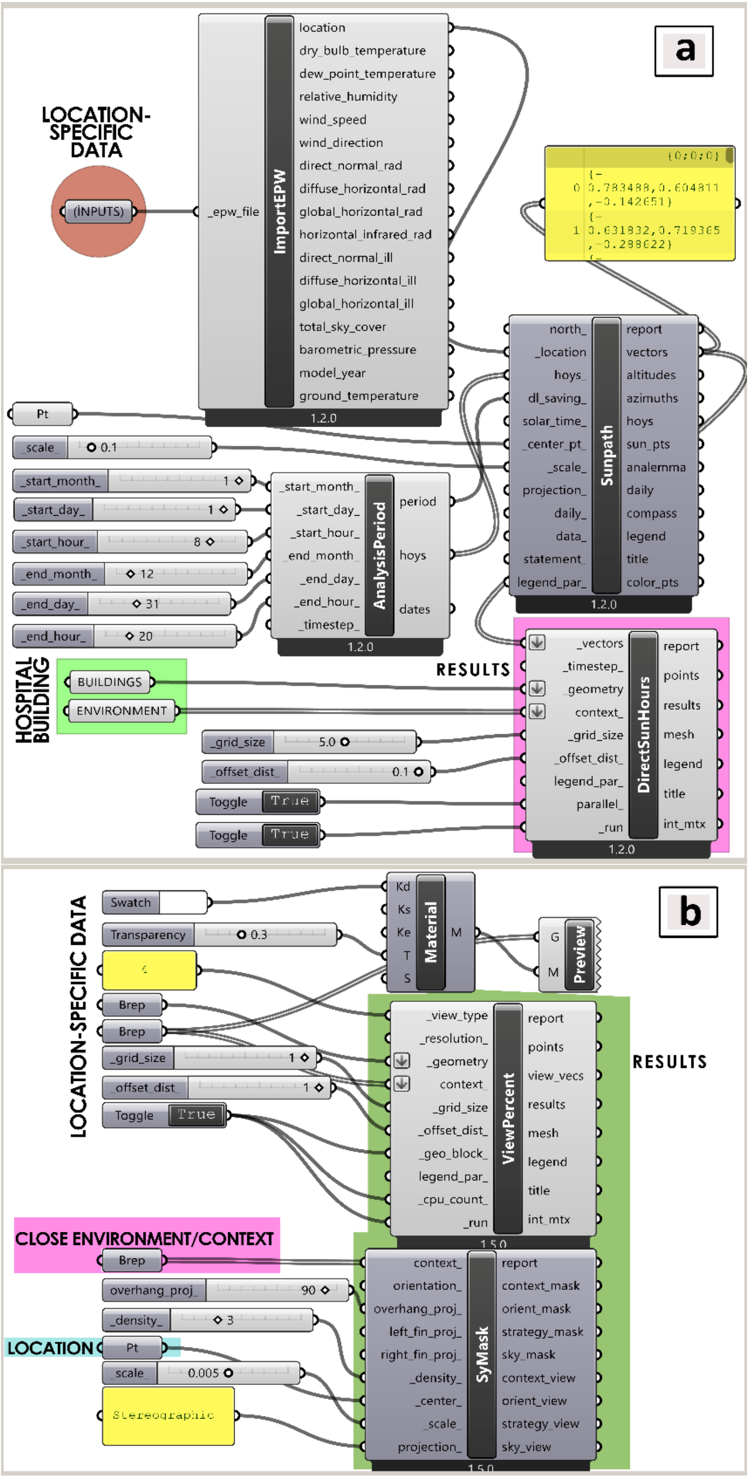

Fig. 4. Algorithms; (a) Algorithm that calculates the direct sun hours, (b) Algorithm that calculates the SVF value.

5. Results and Discussions

5.1. Sun hour test results

Sun hour value was calculated by using the algorithm developed in Rhino and its add-on Grasshopper program, depending on the direct sunning parameter for Konya Numune Hospital, Konya City Hospital and Selçuk University Medical Faculty Hospital (Fig. 4(a)). In the algorithm, the analyses were carried out without considering the existing trees and the sky cloudiness. In addition, the algorithm considers the annual sunshine hours. First of all, the analysis results produced based on the algorithm that calculates the direct sunshine hours within the scope of Konya City Hospital are presented in Fig. 5. According to the results of the analysis, Konya Numune Hospital receives a maximum of 4125 hours of sunshine per year. Annual sunshine hours vary depending on the width, height, and immediate surroundings of the hospital building.

In the courtyard (depending on the width, length, and height) created in the design of Konya Numune Hospital, the facades receive between 0-2062 hours of sunshine per year. It has been observed that the high-rise patient care units facing the south facade of the hospital receive between 2475-4125 hours of sunshine per year. Similarly, it has been observed that the facades where the emergency, polyclinics, staff rooms, and intensive care units are located, which have fewer floors and a courtyard effect, receive between 412-2062 hours of sunshine per year. However, it has also been observed that the areas facing the courtyard in Konya Numune Hospital do not have the opportunity to benefit from the sun.

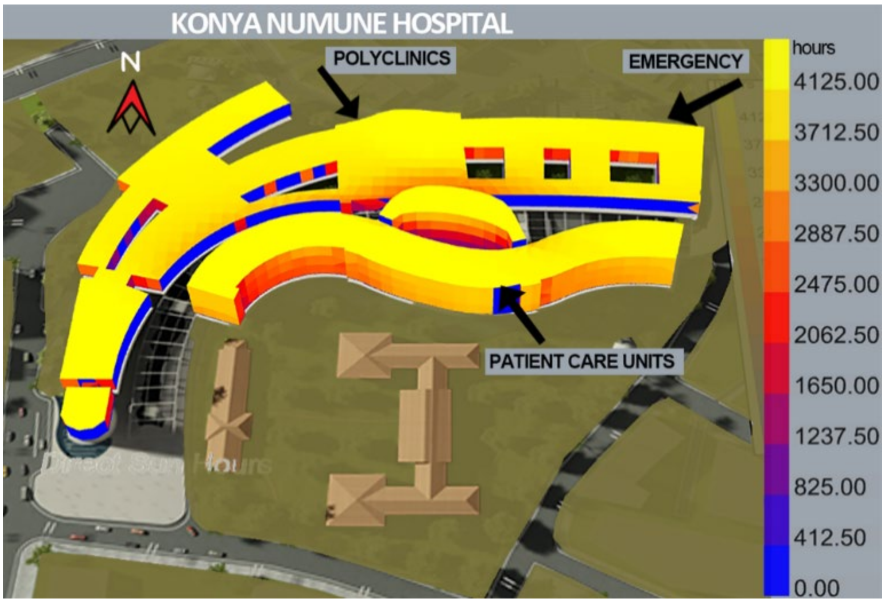

Fig. 5. Sun hour measurements observed at Konya Numune Hospital.

Secondly, the analysis results produced based on the algorithm that calculates the direct sunshine hours within the scope of Konya City Hospital are presented in Fig. 6. According to the analysis results, Konya City Hospital receives a maximum of 4125 hours of sunshine per year. The number of annual sunshine hours a hospital receives depends on the size and surroundings of the building. The design of Konya Numune Hospital creates a narrow canyon effect, which results in sun exposure on the facades for up to 1650 hours per year, depending on their width, length, and height. It has been observed that the patient care units located on the four sides of the hospital receive sun exposure for 3300-4125 hours annually. On the other hand, the blocks containing emergency, polyclinics, staff rooms, and intensive care units, which form a narrow canyon effect with fewer floors, receive sun exposure for 412-1650 hours per year. In Konya City Hospital, it has been observed that areas with a narrow canyon effect do not have the opportunity to benefit from the sun.

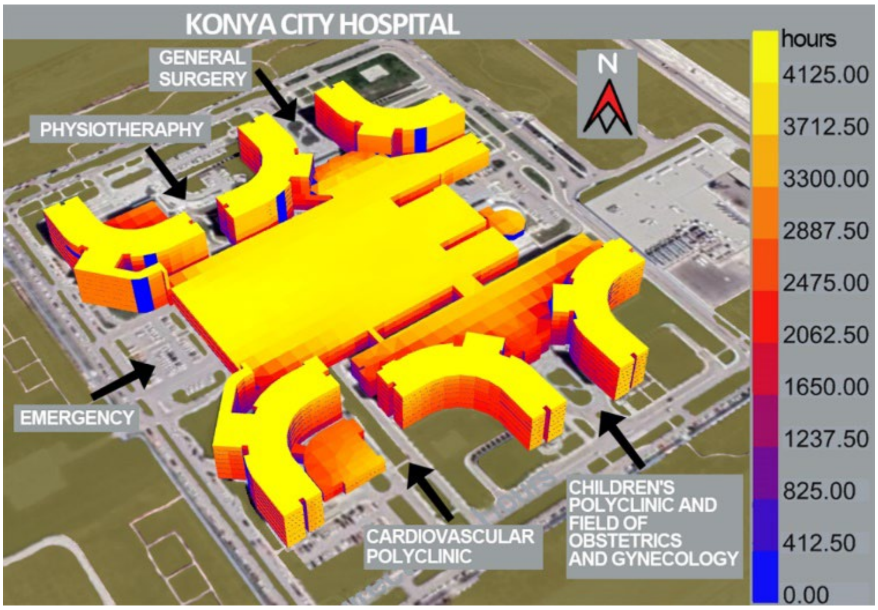

Fig. 6. Sun hour measurements observed at Konya City Hospital.

The analysis results, produced by an algorithm that calculates the direct sunlight hours within the Konya Selçuk University Medical Faculty Hospital premises, are presented in Fig. 7. According to the analysis, the hospital receives a maximum of 4125 hours of sunlight per year, with annual hours varying based on the width, height, and immediate surroundings of the building. The façades in the unused narrow areas of the hospital receive between 0-825 hours of sunlight per year. The high-rise patient care units facing the southeast façade of the hospital receive between 825-4125 hours of sunlight per year. On the facades of emergency, polyclinics, staff rooms, and intensive care units with fewer floors that create a narrow canyon effect, it has been observed that they receive between 412-825 hours of sunlight per year. The areas under the influence of a narrow canyon in Konya Selçuk University Medical Faculty Hospital do not have the opportunity to benefit from sunlight.

The Sun Hour test results for hospitals are presented in Table 1. Narrow or courtyard-style facade designs have created a moderate to high level of canyon effect. This effect has resulted in less annual sun exposure duration observed in areas facing narrow or courtyard spaces.

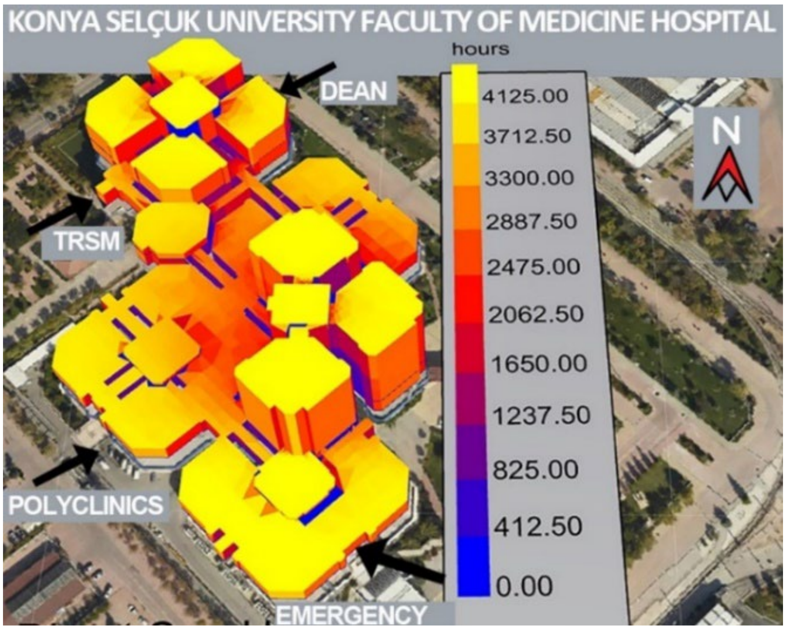

Fig. 7. Sun hour measurements observed at Konya Selçuk University Faculty of Medicine Hospital.

Table 1. Comparison of sun hour test results for hospitals.

	Konya Numune Hospital	Konya City Hospital	Konya Selçuk University Hospital
Annual Maximum Sun Exposure Duration	4125 hours		
Factors Influencing Variation in Annual Sun Exposure Duration	Building height, width, and surroundings		
Annual Duration of Sun Exposure for Facades Facing Narrow Spaces or Courtyards	0-2062 hours	0-1650 hours	0-825 hours
Annual Sun Exposure Duration for Emergency, Polyclinics, Staff Rooms, and Intensive Care Units	412-2062 hours	412-1650 hours	412-825 hours
Impact Level on Facades Facing Narrow or Courtyard	Moderate canyon effect	High-level canyon effect	A high degree of canyon effect

5.2. SVF test results

Experiments were carried out with the algorithm developed in Rhino and its add-on Grasshopper program to evaluate whether it provides health and well-being for patients, staff, and visitors based on the SVF parameter in Konya Numune Hospital, Konya City Hospital, and Selçuk University Medical Faculty Hospital (Fig. 4(b)). The aim of reducing the complexity of the analysis of SVF test results and highlighting the narrow and canyon effect of hospitals has been achieved. To achieve this, the algorithm disregarded trees and the cloudiness of the sky. Furthermore, 12 points, including different locations and environmental conditions with narrow and canyon effects, were identified to evaluate whether the user requirements are met based on the SVF parameter. The test results produced according to this algorithm in Konya Numune Hospital are presented in Fig. 8.

Fig. 8. SVF measurements observed at Konya Numune Hospital.

When Fig. 8 is examined, the percentage of SVF distributions at 12-point locations can be seen. The SVF values of these point locations are 23%, 28%, 10%, 18%, 33%, 7%, 23%, 18%, 27%, 42%, 59%, and 44%, respectively. While most of these points have an SVF value that can be described as close to closed, only the P11 point position can be described as open. The closeness of these point locations to the openness or closure value according to the SVF distributions is expressed in Table 2. Although the courtyard design approach in hospital buildings is important in terms of providing sufficient natural light and ventilation, its lack of width and height that can meet the needs reduces the SVF value. This situation shows that the courtyard design approach has been ignored.

Table 2. Open and closed rates according to SVF values observed at Konya Numune Hospital.

Closed SVF value											**Open SVF value**
Point locations and SVF value											
P6	P3	P4	P8	P1	P7	P9	P2	P5	P10	P12	P11
7%	10%	18%	18%	23%	23%	27%	28%	33%	42%	44%	59%

Secondly, the test results produced based on the algorithm for Konya City Hospital are presented in Fig. 9. When Fig. 9 is examined, the percentage of SVF distributions at 12-point locations can be seen. The SVF values of these point locations are 9%, 32%, 17%, 37%, 13%, 26%, 10%, 16%, 10%, 29%, 9%, and 9%, respectively. These points have SVF values that can be described as close to almost closed. The closeness of these point locations to the openness or closure value according to the SVF distributions is given in Table 3.

Fig. 9. SVF measurements observed at Konya City Hospital.

The main design approach in hospital buildings is to provide sufficient natural light and ventilation. The low density of the built environment around the Konya City Hospital, which was examined in parallel, increases the potential for an unobstructed open sky. However, the lack of sufficient width and height between the mass blocks in Konya City Hospital decreases the SVF value. As a result of this situation, the hospital building provides direct natural light intake, and the level of seeing the sky is at a minimum level.

Table 3. Open and closed rates according to SVF values observed at Konya City Hospital.

Closed SVF value SVF value			⟷								Open
Point locations and SVF value											
P1	P11	P12	P7	P9	P5	P8	P3	P6	P10	P2	P4
9%	9%	9%	10%	10%	13%	16%	17%	26%	29%	32%	37%

Third, the test results produced according to the algorithm specific to Konya Selçuk University Medical Faculty Hospital are presented in Fig. 10. When Fig. 10 is examined, the percentage of SVF distributions at 12-point locations is seen. The SVF values of these point locations are 2.27%, 2.77%, 5.60%, 3.82%, 2.34%, 30.04%, 2.21%, 32.55%, 3.38%, 8.72%, 4.63% and 9.35%, respectively. These points have an SVF value that can be described as almost closed. The closeness of these point locations to the openness or closure value according to the SVF distributions is given in Table 4.

The low built environment density around Konya Selçuk University Medical Faculty Hospital increases the potential for an unobstructed open sky. However, the close positioning of low-rise and multi-storey mass blocks in the Medical Faculty Hospital creates a canyon effect and reduces the SVF value. As a result, the dominant shadow effect caused by the blocks reduces the direct natural light intake of the Medical Faculty Hospital and the level of seeing the sky.

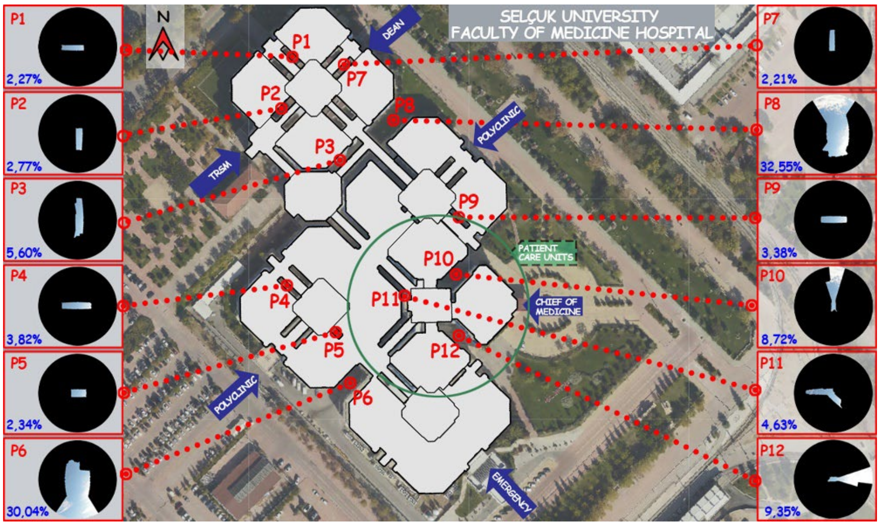

Fig. 10. SVF measurements observed at Konya Selçuk University Faculty of Medicine Hospital.

Table 4. Open and closed rates according to SVF values observed at Konya Selçuk University Faculty of Medicine Hospital.

Closed SVF value SVF value					⟷						**Open**
Point locations and SVF value											
P7	P1	P5	P2	P9	P4	P11	P3	P10	P12	P6	P8
2.2 %	2.2 %	2.3 %	2.7 %	3.3 %	3.8 %	4.6 %	5.6 %	8.7 %	9.3 %	30 %	32.5 %

According to the SVF test results in hospital buildings, areas with roofs and low built environment density have the maximum SVF value and represent a flat and unobstructed surface from the point location to its surroundings. However, the presence of high-rise buildings in areas close to hospital buildings often hinders the visibility of the sky and causes lower SVF values. Hospital facades that can provide direct sunlight and quality ventilation have a high percentage of SVF, is closely related to the spatial distribution and structural characteristics of the buildings. Figure 11 shows the SVF values on the facades of hospital buildings.

When the facades of hospital buildings are examined, high-rise mass blocks that can directly interact with the outside tend to have higher SVF values, while areas, where they form deep canyons (courtyard designs with low width, height, and height ratios), tend to have lower SVF values. When the hospital buildings of three different sizes (Konya Numune Hospital, Konya City Hospital, and Selçuk University Medical Faculty Hospital) determined in Konya are examined, it is seen that while patient care units are generally located in the high-rise mass block, in the mass blocks that will create a canyon effect with fewer floors, emergency, and polyclinics, staff rooms, and intensive care units. Such spatial distribution in hospital buildings is at a high SVF level in patient care units, while it is at a low SVF level in emergency, outpatient clinics, staff rooms, and intensive care units. Surfaces with lower SVF values both heat up more slowly and receive less sunlight due to the presence of shadows from nearby buildings.

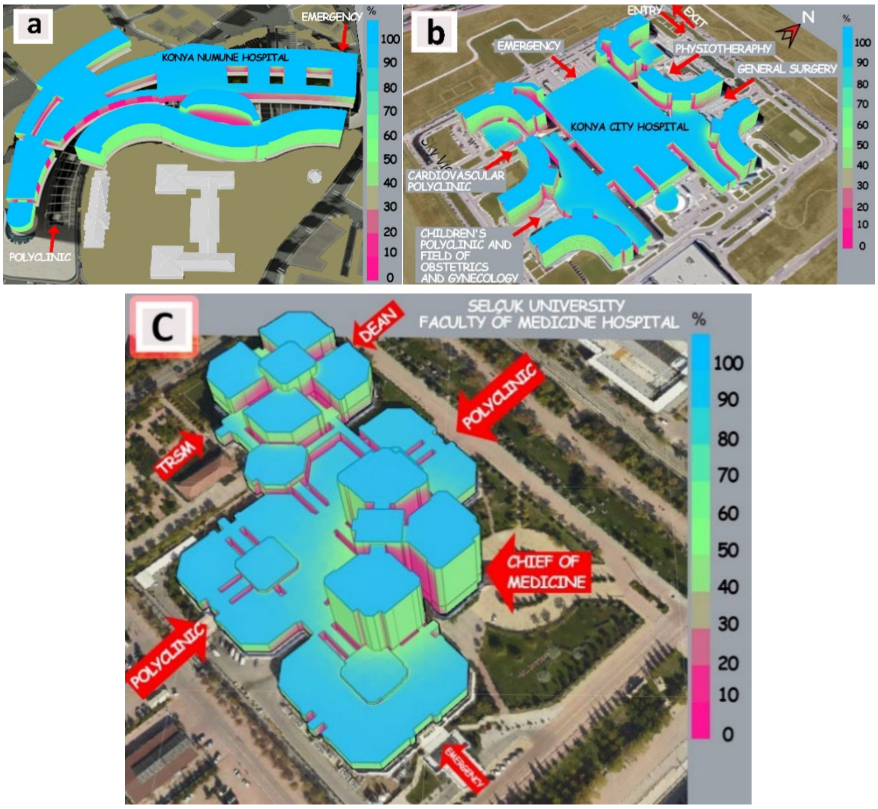

Fig. 11. SVF values observed on hospital facades; (a) Konya Numune Hospital, (b) Konya City Hospital, (c) Selçuk University Faculty of Medicine Hospital.

6. Conclusions and Recommendations

In the design of hospital buildings, it is paramount to incorporate natural sunlight into the spaces to benefit patients from the surrounding views. Close proximity of mass blocks within hospitals may impede sunlight penetration and obstruct panoramic views. Konya Numune Hospital, Konya City Hospital, and Selçuk University Medical Faculty Hospital stand as prominent examples of this issue, designed without due consideration for inter-block distances. In this study, the parametric design method was employed to assess the impact of hospital building forms, along with utilizing algorithms in Rhino and its Grasshopper add-on to analyze sunlight hour and SVF values.

The findings reveal significantly low levels of sunlight hour and SVF values in these hospitals, attributed to the proximity and lack of consideration for immediate surroundings in their design. Incorporating sunlight duration and SVF parameters as design inputs for hospital buildings is crucial. While sunlight hour reflects the sun exposure of the buildings, SVF parameter elucidates the relationship between the built environment and the sky. Thus, integrating these parameters into the design phase is essential for optimizing hospital construction, promoting the health and well-being of patients, staff, and visitors. Designers and architects should aim to create healing environments by considering factors like natural light and visitor-friendly facilities, ensuring that hospital buildings are oriented to maximize exposure to sunlight and sky views for enhanced patient satisfaction and overall well-being.

References

1. Pauley, S.M. (2004). Lighting for the human circadian clock: recent research indicates that lighting has become a public health issue. *Medical Hypotheses*, 63(4), 588-596.
2. Manzoor, S.J.; and Seung, P.J. (2013). An architectural study on the relationship of the skylight and patient's satisfaction at the ambulatory day careward in Agha Khan Hospital Pakistan. *Nursing and Health,* 1(2), 21-30.
3. Olsen, R.V. (1984). The effect of the hospital environment: patient reactions to traditional versus progressive care settings. *Journal of Architectural and Planning Research,* 1(2), 121-136.
4. Timmermann, C.; Uhrenfeldt, L.; and Birkelund, R. (2015). Room for caring: patients' experiences of well-being, relief and hope during serious illness. *Scandinavian Journal of Caring Sciences,* 29(3), 426-434.
5. Seyedahmadi, S. (2019). Role of natural elements in provision of healing environment: Sustainable healthcare building. *European Journal of Sustainable Development,* 8(1),401-401.
6. Siddiqui, Z.K.; Zuccarelli, R.; Durkin, N.; Wu, A.W.; and Brotman, D.J. (2015). Changes in patient satisfaction related to hospital renovation: experience with a new clinical building. *Journal of Hospital Medicine,* 10(3), 165-171.
7. Nimlyat, P.S.; Salihu, B.; and Wang, G.P. (2022). The impact of indoor environmental quality (IEQ) on patients' health and comfort in Nigeria. *International Journal of Building Pathology and Adaptation*. Ahead-of-print.
8. Özdemir, H.; and Çakmak, B.Y. (2022). Evaluation of daylight and glare quality of office spaces with flat and dynamic shading system facades in hot arid climate. *Journal of Daylighting,* 9(2), 197-208.
9. Andersen, M.; et al. (2008). An intuitive daylighting performance analysis and optimization approach. *Building Research & Information,* 36(6), 593-607.
10. Baker, A. (2019). How to calculate your peak sun-hours. *Solar Power Authority*, AR 0078729-AR 0078739.
11. Betti, G.; and Arrighi, S. (2017). A differential growth approach to solar envelope generation in complex urban environments. *Proceedings of the PLEA*2017 *Conference*, Berlin, Germany, 2030-2037.
12. Miao, C. et al. (2020). Review of methods used to estimate the sky view factor in urban street canyons. *Building and Environment,* 168, 106497.
13. Watson, I.D.; and Johnson, G.T. (1987). Graphical estimation of sky view-factors in urban environments. *Journal of Climatology,* 7(2), 193-197.

14. Kim, H.-J.; Choi, W.-S.; and Kim, J.-W. (2022). A study on parametric design tools for residential buildings securing valid sunlight hours on the winter solstice. *Journal of Asian Architecture and Building Engineering,* 21(5), 1657-1676.
15. Suk-Jin, J.; and Seong-Hwan, Y. (2015). Analysis on the influence of building coverage ratio and floor area ratio on sunlight environment and outdoor thermal environment in flat-type apartment houses. *Journal of the Architectural Institute of Korea Planning & Design,* 31(5), 69-76.
16. Canan, F. (2008). *Enerji etkin tasarımda parametrelerin denetlenmesi için bir model denemesi.* PhD Thesis, Department of Architecture, Selçuk University.
17. Luca, F.D.; and Voll, H. (2017). Computational method for variable objectives and context aware solar envelopes generation. *Proceedings of the Symposium on Simulation for Architecture and Urban Design*, Toronto, Canada, 353-342.
18. Lu, M.; and Du, J. (2013). Assessing the daylight and sunlight availability in high-density residential areas: a case in North-east China. *Architectural Science Review,* 56(2), 168-182.
19. Chatzipoulka, C.; Compagnon, R.; Kaempf, J.; and Nikolopoulou, M. (2018). Sky view factor as predictor of solar availability on building façades. *Solar Energy,* 170, 1026-1038.
20. Silva, L.T.; Fonseca, F.; Rodrigues, D.; and Campos, A. (2018). Assessing the influence of urban geometry on noise propagation by using the sky view factor. *Journal of Environmental Planning and Management,* 61(3), 535-552.
21. Kakon, A.N.; and Nobuo, M. (2009). The sky view factor effect on the microclimate of a city environment: A case study of Dhaka city. *Proceedings of the 7th International Conference on Urban Climate,* Yokohama, Japan, 1-4.
22. Özdemir, H. (2023). *A parametric model proposal in the context of climate responsive design: The case of Izmir/Seferihisar*. PhD Thesis, Department of Architecture, Konya Technical University.
23. Lagios, K.; Niemasz, J.; and Reinhart, C.F. (2010). Animated building performance simulation (ABPS)–linking Rhinoceros/Grasshopper with Radiance/Daysim. *Proceedings of SimBuild,* New York, USA, 4(1), 321-327.
24. Ladybug. (2023). EPW Map. Retrieved June 1, 2023, from https://www.ladybug.tools/epwmap/#close
25. Li, W.; Putra, S.Y.; and Yang, P.P.-J. (2004). GIS analysis for the climatic evaluation of 3d urban geometry: The development of GIS analytical tools for sky view factor. *Proceedings of the 7th International Conference on GIS and Developing Countries* (*GISDECO* 2004), Johor Bahru, Malaysia, 1-10.