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Original Research Article

Integrated Analysis of Daylight Metrics in Elderly Housing Design (A Case Study of Isfahan)*

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Abstract

Problem statement: In hot–arid climates, effective use of natural daylight is one of the key factors in improving the quality of life for the elderly, as daylight not only has physiological and psychological benefits but also reduces dependence on artificial lighting. However, many elderly housing complexes in this climate face challenges in meeting natural lighting standards.

Research objective: The aim of this study is to quantitatively analyze key daylight performance indicators including Daylight Autonomy (DA), Spatial Daylight Autonomy (sDA), Useful Daylight Illuminance (UDI), and Sky View Factor (SVF) in selected elderly housing units in the city of Isfahan. To achieve this goal, field data were collected using a lux meter at different times of day and then validated through precise simulations in Dialux and Ladybug software.

Research method: This study combines a field-based approach (measuring ambient light with a lux meter at various times of the day) with detailed simulations conducted using Dialux and Ladybug to evaluate the daylighting conditions of the examined spaces.

Conclusion: The results showed that many of the studied spaces do not meet desirable levels in terms of DA and sDA, although a limited number of areas were able to provide natural light within the optimal UDI range (100–3000 lux). Moreover, SVF values in some spaces particularly in northern zones or areas affected by external shading elements were lower than standard thresholds. Overall, the findings indicate that the current design of elderly housing in hot–arid climates does not fully align with the daylighting requirements of this population group.

Keywords: *Daylight, Elderly Housing, Hot-Arid Climate, Daylight Metrics, Daylight Simulation.*

Introduction

Designing residential spaces for the elderly is one of the fundamental challenges of contemporary architecture. The increase in life expectancy and the increasing share of the elderly in the population structure have doubled the necessity of creating environments that are appropriate for the needs of this group. In such circumstances, natural light -as one of the most important environmental elements- plays a decisive role in improving the quality of life of the elderly. Daylight is not only a factor in lighting the space but also affects various aspects of physical and mental health. Regulating circadian rhythms, improving sleep quality, boosting mood, and improving cognitive performance are among the functions that are directly related to the proper utilization of natural light. In addition, daylight can play a role in increasing the safety of the spaces

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because it helps to improve eyesight, reduce the risk of falls, and enhance the elderly's ability to navigate.

Despite the aforementioned importance, housing design has been associated with special limitations and difficulties in hot-arid climates. High radiation intensity, day and night temperature fluctuations, as well as the need to manage energy consumption, make it necessary to achieve a balance between providing sufficient lightning and controlling the heat load. In the elderly housing, this necessity takes on broader dimensions, because in addition to providing lighting, glare, light fluctuations, and creating unsafe conditions must be prevented, too. On the other hand, many common standards in the field of lightning have been developed based on the needs of the younger population and do not fully cover the visual sensitivities of the elderly. Decreased eyesight, decreased ability to distinguish colors, and the need for higher light intensity are among the characteristics of aging that have received less attention. For this reason, most of the elderly face some problems, such as low light, glare, and inconsistency between natural and artificial light in their residential spaces.

Accordingly, the main issue of the present research focuses on examining the current condition of elderly housing in a hot-arid climate and their degree of compliance with the lighting requirements of this group. The lack of a comprehensive analytical approach that simultaneously considers quantitative daylight metrics has limited the opportunities for design optimization. Therefore, this study, focusing on the city of Isfahan, conducts an integrated analysis of the Daylight Autonomy (DA, SDA, CDA), useful daylight illuminance (UDI), and sky view factor (SVF). The aim is to clarify which indicators (metrics) have the greatest impact on the lighting quality of elderly residential spaces and how they can be combined to improve lighting conditions appropriate to the needs of this group in hot-arid climates.

Theoretical Foundations and Literature Review

Daylight, as one of the most fundamental environmental factors in architectural design, plays a key role in improving the quality of life of residents, especially in elderly residences that are more sensitive to light conditions. Natural light not only helps reduce energy consumption but also has wide-ranging effects on mental health, circadian rhythm, sleep, mood, and cognitive function of the elderly (Mardaljevic et al ., et al, 2022 Figueiro et al, 2020). Therefore, a detailed analysis of daylight metrics is considered essential in order to optimize architectural designs, especially in hot-arid climates.

- **Definition and importance of daylight in residential architecture**

Daylight refers to light that enters an interior space through natural sources such as the sun and includes direct light, diffuse light from the sky, and light reflected from exterior surfaces (Boubekri, 2008). Utilization of natural light in architecture is considered one of the key design principles and has an impact on visual comfort, energy savings, and improving the quality of users (Reinhart & Galasin, 2006). This issue is doubly important in residential architecture, especially in hot-arid climates where the intensity of radiation is high; On the one hand, it is necessary to provide sufficient lighting, and on the other hand, it is essential to prevent glare and increased thermal load (Taleghani et al., 2014). From the human point of view, daylight, in addition to its function, plays an important role in regulating the circadian rhythm and is effective in improving sleep quality, reducing depression, and supporting cognitive function (Figueiro et al, 2020). This is especially important for the elderly because eyesight loss, decreased color cognition, and the need for higher light intensity make them more vulnerable to a lack of natural light (Van Hoof et al., 2021; Figueiro et al., 2008). As a result, providing appropriate lighting conditions in the elderly residential spaces can prevent motor errors and falls and also increase satisfaction and social interactions (Brawley, 2001; Choi & Beltran, 2022). International standards such as EN 17037 and WELL Building Standard also emphasize the need for adequate access to daylight in indoor spaces and consider it not only a functional factor, but also a vital component for public health (CEN 2019; WB102020). In this regard, scientific metrics such as Daylight Autonomy (DA), Spatial Daylight Autonomy (SDA), and Useful Daylight Illuminance (UDI) are important tools for measuring the quality of light (Reinhart et al, 2011). These indicators (metrics) allow designers to simulate and quantitatively assess light conditions and provide a basis for design decisions. Considering the growing trend of the elderly population and their desire for independent living, paying attention to the quality of natural light in housing design has become one of the requirements of contemporary architecture. Designs that ensure sufficient light can contribute significantly to promoting self-reliance, comfort, and well-being of the elderly (Zadeh et al., 2022).

- **Main metrics of daylight analysis**

Valid international metrics are used to quantitatively and qualitatively assess natural light in residential spaces, especially for sensitive groups such as the elderly Table 1. The most important of them are as follows.

- **Relevant international standards**

To evaluate and design natural lighting in architecture, international reference standards are used, of which the most important are as follows:

LEED v4 (U.S. Green Building Council): This standard incorporates SDA and ASE (Annual Sunlight Exposure) for assessing daylight quality and requires a minimum of SDA 55% for indoor spaces (USGBC, 2021).

WELL Building Standard: It focuses on the health and biological effects of light and considers daylight as a factor in regulating circadian rhythms and promoting the well-being of users, especially in residential and healthcare spaces (IWBI, 2020).

EN 17037 (European standard): It is the European standard for daylight assessment, which defines minimum reference values for illuminance level and outward visibility. This standard emphasizes that daylight, in addition to its functional role, is a part of the spatial quality and general health of the occupants (CEN, 2019).

Theoretical Framework

The theoretical framework of this research is based on the causal relationship between inputs, mechanisms, daylight metrics, and human and

Table 1. Main Metrics of Daylight Analysis. Source: Authors.

Metrics	Definition	Dimensionless	Threshold	Importance for the elderly	Source
SVF-sky view Factor	The ratio of the available field of view to the sky from a given point in open or semi-open space	(6 to 1)	Reference higher values indicate more daylight reception	SVF limitation in hot-arid climates reduces light penetration into interior spaces	Compagn 2004; Talegha et al., 2014
DA-Daylight Autonomy	The percentage of hours per year that the illumination of a point reaches the required level with natural light alone.	%	Typically 300 lux for 50% of the hours	For the elderly, 300-500 lux is recommended	IES,2020 Rogers et al., 2020
SDA-spatial Daylight Autonomy	percentage of the surface area of a space where a minimum level of illumination is maintained for a major Part of the year	level %	SDA 55% (according to LEED V4)	important indicator in living and sleeping spaces for the elderly	Reignbar et al, 2011
UDI - Useful -Daylight Illuminance	percentage of Hours per year when light intensity is within the useful range (100-200 lux)	%	100-2000 lux	Above 2000 lux can cause glare in the elderly	Mardaljevic & Christoffersen 2019
CDA-continuous Daylight Autonomy	Similar to DA, but it also considers light intensity above the reference value and is measured continuously.	%	Threshold 200lux(in some Studies)	It is useful to assess Depth lighting of spaces in open Plans	Galasiu et al., 2021

functional outcomes. This framework aims to show how climate and design variables affect quantitative and design lighting metrics through mediating mechanisms and ultimately improve the quality of life of the elderly.

-Inputs: This section includes geometry (dimensions, depth of space, position of openings), climatic characteristics (intensity and direction of radiation, temperature changes, and materials (reflectance and light transmission coefficients). Prioritizing these variables shows that geometry and climate have a greater contribution to determining the lighting conditions, while materials act as a complementary factor.

-Mechanisms: Inputs affect lighting quality through mechanisms such as sky view factor (SVF), the amount of shading, and light transmission of windows. These mechanisms are interrelated; For example, reducing SVF not only limits sky view but also negatively impacts UDI and DA.

-Daylight Metrics: The quantitative results of the analysis are calculated in the form of DA, SDA, UDI, CDA, and SVF. These metrics are evaluated in clusters to show how changes in inputs and mechanisms affect natural light simultaneously.

-Human and Functional outcomes: The final effects of the metrics are explained at three levels of outcomes.

1- Functional level: Visual lighting autonomy and glare reduction.

2- Psychobiological level: Improving circadian rhythm, sleep, and mental health.

3- Social-conceptual level: Improving spatial quality, satisfaction, and increasing social interactions of the elderly.

This framework guides the research process by showing the priority and reciprocal relationships between variables, but is also used as an analytical reference in the "Discussion section". As a result, both the theoretical link and practical direction of the research are clearly identified (Fig. 1).

Research Background

In recent years, attention has been increasingly focused on the role of daylight in improving the quality of life of the elderly in housing projects, especially in areas with hot-arid climates. Several studies have examined the quantitative and qualitative metrics of natural light in residential spaces and each of which has paid attention to sustainable design from a specific perspective for example, Aghamolaei et al., (2024) analyzed daylight in residential units in hot regions of Iran and showed that the angle of radiation, window height and materials color have significant impact on achieving appropriate lighting. In addition, in a study by Ghasemi et al (2020) on indigenous buildings in Yazd, the relationship between the ratio of transparent walls to the entire building surfaces and UDI was investigated, and it was determined that the form and texture of the building play a decisive role in regulating the distribution of daylight. In a similar study, Mousavi and Behzadfar

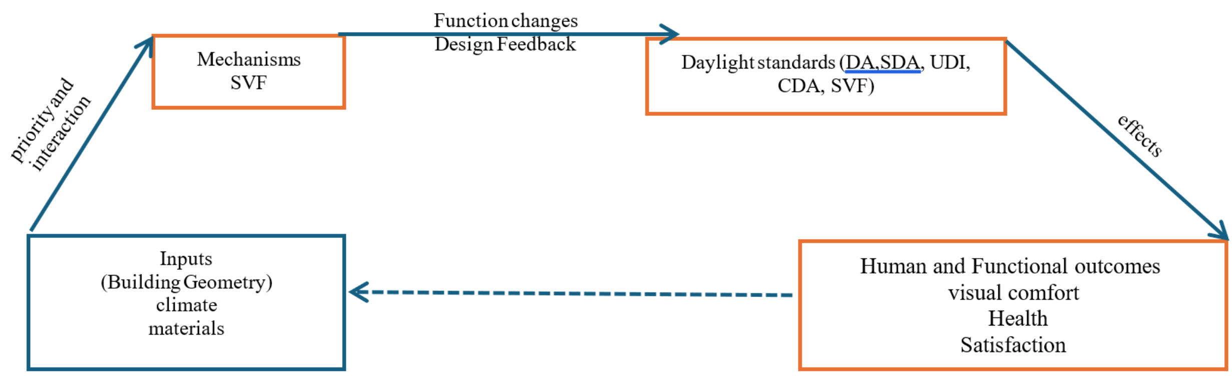

Fig. 1. Theorical Framework Authors.

(2021) examined traditional houses in Kashan. They emphasized that the central courtyard of high windows can simultaneously contribute to natural ventilation and increase the depth of light penetration. These findings were consistent with the results of Alwetaishi (2020) in the Saudi Arabian climate, which confirmed the effect of traditional strategies on desirable indoor lighting.

Internationally, studies such as Lopez et al (2022) and van Hoof et al. (2021) emphasized the importance of natural light on the elderly in care facilities and found that inappropriate lighting design increases stress, sleep disturbance, and even the inability to recognize directions by the elderly. Reinhart et al. (2011) and Marolaljevic et al. (2012) introduced some metrics, such as DA and SDA, and paved the way for quantifying the quality of daylight. However, the application of these metrics in the design of elderly housing remains limited, especially in the field of climatic architecture in arid regions. From a standardization perspective, Standards such as EN 17037 and WE[11] have provided specific criteria for supplying natural light, but they need to be localized in accordance with Iran's climatic requirements and the physiological characteristics of the elderly (CEN, 2019; IWBI, 2020). Despite numerous studies, there are several key gaps in the field of daylight in the elderly housing in hot-arid climates.

-Lack of comprehensive integration of optical metrics such as DA, SDA, UDI, and SVF in the integrated analysis of the design.

-Lack of numerical and simulated studies in the field of daylight design specifically for the elderly population.

-Failure to localize international standards based on Iran's climatic conditions.

-Lack of attention to the non-visual effects of natural light (Melanopic lighting) in the design of housing for the elderly.

-Lack of sufficient case studies in the field of adapting form, orientation, and architectural materials with appropriate optical (visual) function in the hot-arid regions of Iran.

These cases demonstrate the need for Comprehensive research focusing. On an integrated analysis of daylight metrics in the sustainable design of elderly housing (Table 2).

Research Methodology

This research was of an applied-developmental type and was conducted using a mixed-method (quantitative-qualitative) and an analytical-descriptive method. It aimed at evaluating the quality of natural light in the design of elderly housing with an emphasis on comprehensive daylight metrics in the hot and arid climate of Isfahan. The methodological framework was designed in such a

Table 2. Research Background. Source: Authors.

Name of the Researcher	Year	The title of the study	Region	Research Method	(Optical Visual) Metrics	Target population	Research Gap
Aghamolaei et al.	2022	studying daylight function in tropical buildings	South of Iran	DIALux simulation	DA, UDI	general	lack of focus on the elderly
Ghasemi et al.	2020	Analysis of natural light in Yazd's local architecture	Yazd	Simulation & field analysis	UDI	general	lack of a combined analysis of metrics
Mousavi & Behzad Far	2021	Investigating the effect of the central courtyard on lighting	Kashan	Qualitative	lighting Distribution	general	lack of attention to numerical Metrics
López et al.	2022	Lighting evaluation in the elderly centers	Spain	Field Measurement	DA, SVF	The Elderly	lack of climate adaption
Van Hoof et al.	2021	Environmental design for the elderly	Netherlands	systematic review	general light	The Elderly	lack of investigation of the arid climate
Alwetaishi	2020	Daylight analysis in the arid climate. of Saudi Arabia	Saudi Arabia	Simulation	SDA, DA	general	lack of focus on Specific Groups

way that it would be possible to accurately analyze the parameters affecting natural lighting in elderly residential spaces (Table 3). Data were collected from two main ways.

-Dynamic Simulation: It was performed using the Ladybug 1.4. 0 extension in Grasshopper-Rhino 7 setting and the Isfahan climatic file of Epw. The sampling network was set up based on a 0.5□0.5m grid and one year. The metrics under study, including CDA, UDI, SDA, and SVF, were calculated at three heights (According to the line of sight of sitting or lying position in the elderly) and in selected rooms (rooms 2, 7, 12, 17).

-Field measurement: Data of illuminance intensity (Lux), temperature, and relative humidity were recorded using a lux meter and a digital thermometer on several consecutive days at 9, 12, and 3 pm. These data were the reference for simulation validation (Fig. 2). The case study included residential buildings of the elderly in the central texture of Isfahan, which were selected purposefully regarding space depth, percentage of openings, and shading (tall trees, parapets, canopies). Supplementary information was collected by observation, photography, interviews with the residents, and architectural plans (Figs. 3, 4).

Table 3. Input characteristics of the research. Source: Authors.

Type of data	Tools/source	Description
climatic file	(Isfahan) Epw	one-year climatic data
software	Rhino 7+ Grasshopper+ Ladybug 1.4.0	dynamic Simulation of daylight
Metrics	SDA, UDI, CDA, SVF	selected metrics of daylight
height of the work surface	0.8, 1.1, 1.0 meters	equivalent to the line of sight of the sitting/ lying position in the elderly.
Field tools	Luxmeter, Digital thermometer	Measurement at 9, 1, and 3:00 p.m

Fig 2. Light intensity measuring device (Lux meter model ST-1301). Source: Authors.

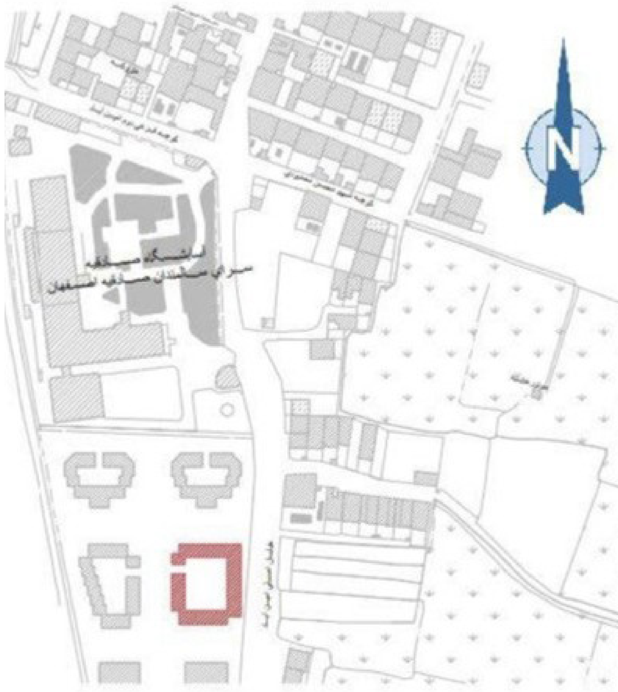

Fig. 3. Location of the building in Isfahan city. Source: Authors.

Fig. 4. Images of the elderly housing (selected case study). Source: Author's archive.

First, field measurements were performed to obtain actual environmental data. Then, a dynamic simulation was performed based on the inputs, and its results were compared with field data. If there is a difference, the simulation model will be calibrated. In this way, the field results played a reference role for simulation validation. Validation was performed by comparing the simulation results and field data. Statistical criteria included.

-RMSE (Root Mean Square Error),

-To evaluate the overall error,

-MAE (Mean Absolute Error): For mean absolute error,

-MBE (Mean Bias Error): To examine the tendency of the model to overestimate or underestimate.

The simulation results were organized in Excel software. The surface Mean, maximum, minimum, and standard deviation were calculated. The outputs were analyzed and classified in the form of heat maps and tables based on EN 17037, LEED, ASHRAE, and WE[11] Standards. In the section SVF, geometric visualization from obstacles around the building was used to determine the percentage of direct sky view.

Analysis of Findings

This section analyzes daylight metrics in selected spaces of the elderly housing (rooms 2,7,12,17). The data includes simulation results with the Ladybug plug-in (extension) and field measurements (Lux meter), and the results are organized within the framework of the research objectives.

- **CDA (continuous daylight autonomy)**

CDA represents the percentage of time that the natural light intensity at a point in space exceeds a defined threshold (200lux). Its formula is defined as follows.

Formula (1)

cDAX =Ttotal Tdaylight, x≥Emin×100

In which.

-$T_{daylight} \geq E_{min}$: The sum of the times during the day when the natural light intensity at a point is above a defined minimum threshold (e.g., 200 lux).

-T_{otal}: Total time evaluated per day.

Simulations were done at three heights (0.8, 1, and 1.1 m). Sample results have been shown in the form of heat maps (Fig. 3 Heatmap of DA distribution in room 17 at a height of 0.8m).

Continuous Daylight Autonomy (CDA)-Room 17 at-0.8m.

The simulation was done at three key heights (-0.8, -1, 1.1m) and in three different rooms. The results were analyzed by location and height in the form of heat maps. An example of the maps is given below (the above Fig. 5 is for Room 17 at a height of 0.8m). Finally, the results show that (Table 4).

- **Analysis of SDA**

SDA represents the percentage of space area where natural lighting of at least 300 lux is maintained for more than 50% of the hours (Table 5). The highest acceptable level was observed in room 02. In rooms with south-facing windows and wider openings, the SDA was higher than 45%, while in shaded spaces, the index (metrics) was recorded below the recommended WELL and LEED values (Table 6).

- **UDI**

UDI shows the percentage of hours per year that the light intensity is between 100 and 2000 Lux. The findings show that areas close to the window have

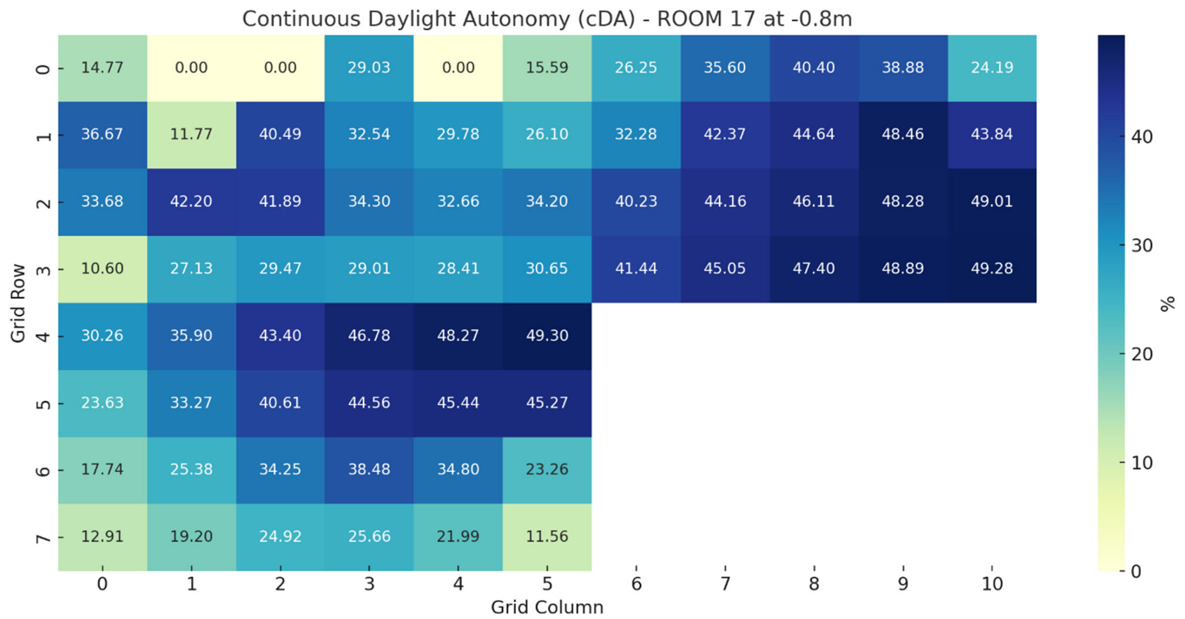

Fig. 5. Heat map of CDA distribution. Source:Authors.

Table 4. Mean and range of CDA in rooms. Source: Authors.

Min cDA (%)	Max cDA (%)	Mean cDA (%)	Height (m)	Room
3.01	49.15	36.29	-0.8	Room 17
3.23	48.27	36.27	-1	Room 17
4.82	49.68	35.63	-1.1	Room 17
2.64	49.38	35.3	-0.8	Room 12
0.36	49.78	36.41	-1	Room 12
4.16	47.06	33.52	-1.1	Room 12
4.89	49.61	37.67	-0.8	Room 07
3.9	48.38	37.79	-1	Room 07
0.72	48.92	33.71	-1.1	Room 07
2.07	48.57	38.67	-0.8	Room 02
2.28	49.32	34.59	-1	Room 02
3.09	47.06	36.41	-1.1	Room 02

Table 5. Mean and Range of SDA. Source: Authors.

Quality evaluation level	Minimum (%)	Max (%)	Mean of sDA(%)	Analysis Height(m)	Room
Relatively Desirable	11.6	49.3	41.2	-0.8	Room 17
Desirable	11.07	49.18	42.7	-1	Room 17
Relatively Desirable	10.96	49.04	41.5	-1.1	Room 17
Desirable	11.43	49.33	43.1	-0.8	Room 07
Desirable	10.89	49.25	44.5	-1	Room 07
Desirable	21.22	48.82	42.3	-0.8	Room 02
Desirable	18.63	49.27	43.7	-1	Room 02
Desirable	20.16	49.26	44.1	-1.1	Room 02

Table 6. UDI Results in selected spaces. Source: Authors.

performances Interpretation	Range above 3000 (%)	Range below 100 (%)	Range 100-3000 lux (8)	Analysis Height(m)	Room
desirable	5.3	18.2	76.5	-1.0	Room 17
Relatively desirable	4.6	20.6	74.8	-1.1	Room 17
desirable	4	17.1	78.9	-1.0	Room 07
Relatively desirable	6.6	19.3	74.1	-0.8	Room 02
desirable	4.6	20.1	75.3	-1.1	Room 02
Relatively desirable	5.7	21.7	72.6	-1.0	Room 12

high UDA values (60-80%) while more distant areas have a noticeable drop (up to 30%). It highlights the need to design side openings or skylights.

- **Analysis of the sky view factor**

(SVF) SVF or sky view Factor represents the ratio of the visible sky area from a given point to the entire celestial hemisphere and is expressed with values between 0-1. In this study, to measure the degree of visual access to the sky, SVF analysis was performed using the Ladybug tool, considering the shading of trees, canopies, and nearby buildings (Table 7).

The results show that units facing the courtyard or with shorter parapets had higher SVF (0.45-0.65). In contrast, shading by tall trees and dense walls reduced SVF to a bout 0.3, which also directly affects the reduction of DA and UDI.

- **Validation results**

Validation of the simulation model was done, and it aims to ensure that computational results correspond to real conditions. For this purpose, field data including illuminance intensity (lux) was collected using a digital lux meter and environmental conditions (temperature and humidity) with a thermometer on several consecutive days at 9, 12, and 3: 00 p.m. The measurements were done in selected rooms (02,07, 12, and 17) and three analytical heights (0.8, 1, and 1. 1 m) to represent the living conditions of the elderly in sitting and lying positions. The simulation outputs were extracted using the Ladybug plugin in the Grasshopper-Rhino environment and compared with field data. The following statistical criteria were used as error Measurement metrics:

-RMSE = 18. 7 lux: It represents the overall deviation between the simulated and measured data. This value indicates that the error dispersion is at an average and acceptable level.

-MAE = 12. 4 lux: The mean absolute error represents the difference in the mean without considering the direction of the error. It also indicates the relative accuracy of the model in reproducing the illuminance intensity.

-MBE = 4. 6 lux: Mean Bias error that indicates the model's tendency to underestimate. Investigations showed that the cause of this tendency is due to environmental factors such as the presence of semi-transparent curtains, internal reflective surfaces, and temporary changes in sky conditions at the time of field collection, which were not fully considered in the simulation.

To clarify the data matching trend, a graphical comparison between the measured values was drawn (Fig. 3). As the graph shows, the pattern of illuminance changes has been similar in the two datasets, and only in some places, the simulation model underestimates the actual data. This overall correlation indicates the model's ability to represent the actual daylight conditions in the studied space.

Considering the RMSE and MAE analysis within an acceptable range and slight tendency, it can be concluded that the simulation model has sufficient accuracy for analysis of metrics, including Daylight Adequacy (DA, SDA, CDA), useful utilization of daylight, and sky view Factor (SVF). Therefore, the quantitative findings from the simulation can be a reliable basis for analysis and interpretation in the next steps of the research (Fig. 6).

Table 7. Results of SVF in selected rooms. Source: Authors.

Position	Mean of SVF	Minimum	Maximum	Effective geometric conditions	Interpretation of access to the sky
Southern room 17	0.42	0.31	0.58	Adjacent to the L-shaped wall + shadow of the trees	limited
Eastern room07	0.53	0.4	0.62	Adjacent to the yard + shallow canopy	relatively open
Northern room 02	0.38	0.29	0.51	closed orientation + height of side wall	limited
Central room 12	0.47	0.36	0.61	Semi-enclosed with medium height	average

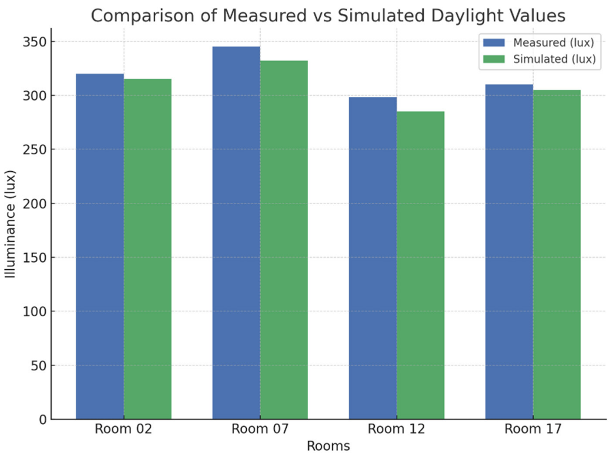

Fig. 6. The difference between field and simulated data for selected rooms. Source: Authors.

Conclusion

The present study aimed to conduct an integrated analysis of daylight in elderly housing in the hot-arid climate of Isfahan. The results showed that CDA, UDI, SDA, and SVF metrics are key tools for assessing the quality of natural lighting and can provide a clear answer to the main question of the research about daylight autonomy and distribution in elderly spaces. The key achievements are as follows:

-The mean of CDA did not exceed 40% in any of the rooms under study, indicating the need to improve lighting uniformity.

-SDA reached higher levels (around 45%) in rooms with southern and larger openings, while northern spaces performed worse.

-UDI was within the desirable range of 70-80% near the openings, but dropped significantly in the depth of space.

-SVF was reduced to low values (around 0.3) under the influence of shading from trees and adjacent walls, which directly affected the reduction of DA and UDL.

In terms of limitations, the present study focused on only one case study in Isfahan and did not examine. Conditions or Seasonal compare them with other climates. In the direction of future research, combining daylight analysis with thermal and psychological metrics of the elderly can provide a more comprehensive picture of environmental quality.

Suggestions

Based on the findings of this study, the following practical and research recommendations are presented.

- **A) Design and architecture.**

-Utilization of international standards such as EN 17037 and WELL for assessing daylight in elderly housing.

-Optimization of building orientation and decrease of shading obstacles (such as high parapets, tall trees nearby).

-Design of the openings that are appropriate for the line of sight of the elderly in sitting and lying positions.

- **B) Executive**

The use of transparent materials with a high transmission coefficient (such as double-glazed windows with appropriate light transmission)

-Prediction of ceiling or side skylights to improve light distribution in the depth of the space.

- **C) Research**

-Simultaneous study of light and thermal metrics in different seasons of the year.

-Study of psychological and physiological effects of natural light on the elderly.
-The use of new technologies, such as environmental sensors and Augmented Reality, to record and analyze data more accurately.

Conflict of Interest

No conflict of interest has been declared by the authors.

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