

# Daylight Strategies and Design for Self-Isolation of COVID-19 in Dwelling

## (Case Study: Maulizarsyah's House, Kampung Laksana, Banda Aceh, Indonesia)

Muhammad Heru Arie Edytia<sup>1</sup> Erna Meutia<sup>1</sup> Zulhadi Sahputra<sup>1,\*</sup> Teuku Zakiyul

Maulana<sup>1</sup> Adelia Adelia<sup>1</sup> Iffah Aqila<sup>1</sup> Siti Afifah Mawaddah<sup>1</sup>

<sup>1</sup> Architecture Program, Department of Architecture and Planning, Faculty of Engineering, Universitas Syiah Kuala, Banda Aceh, Indonesia

\*Corresponding author. Email: [zulhadi.sahputra@unsyiah.ac.id](mailto:zulhadi.sahputra@unsyiah.ac.id)

### ABSTRACT

A dwelling as a self-isolation space becomes essential in the outbreak of COVID-19 to confirm positive or asymptomatic patients. As Wirz-Justice et al. (2020) argue that by its ultraviolet radiance can be considered as a disinfectant and drug to treat the immune system, daylight is needed to cure those patients. However, dwelling users in densely populated areas are struggling to be exposed to daylight in the right amount. This paper aims to propose and explore the daylight strategies and design of self-isolation spaces of dwellings in dense areas. The dwelling model is simulated and explored using Andrewmarsh PD: 3D Sun-Path and VELUX Daylight Visualizer 3. The daylight analysis is detailed using Andrewmarsh PD: Dynamic Daylight and VELUX Daylight Visualizer 3. The data obtained are used to explore the position and size of openings which let the required amount of daylight in a particular time. As a final simulation and exploration, this study suggests strategies and design recommendations for a healthy space of self-isolation.

**Keywords:** COVID-19, Daylight, Dwelling, Self-isolation space, Simulation.

## 1. INTRODUCTION

Since isolation, as shown in settings of a health facility, is the separation of confirmed positive or asymptomatic persons from non-infected persons [1] becomes essential to break the chain, a dwelling as a self-isolation space becomes essential in the outbreak of Severe Acute Respiratory Syndrome CoronaVirus-2 (SARS-CoV-2) or COVID-19 to confirmed positive or asymptomatic patients [2]. In order to protect inhabitants from threats, activities and other layers occurring in the domestic environment should be adapted and transformed [3]. One of the adaptations of those layers, isolation space should be considered in dwelling as threshold space [2].

Natural daylight exposure and getting adequate sleep are one of the important factors in increasing the immune system [4]. As Wirz-Justice et al. [5], Ratnesar-Shumate et al. [6] argues that its ultraviolet radiance can

be considered as a disinfectant and drug to treat the immune system, daylight is needed to cure those patients. Its exposure also increases the recovery rate of COVID-19 patients [7]; in another study, high levels of vitamin D significantly reduced inflammatory markers in patients with COVID-19 without any negative effects [8]. Based on the results of those studies, daylight exposure helps not only the body's resistance during the pandemic but also in its recovery.

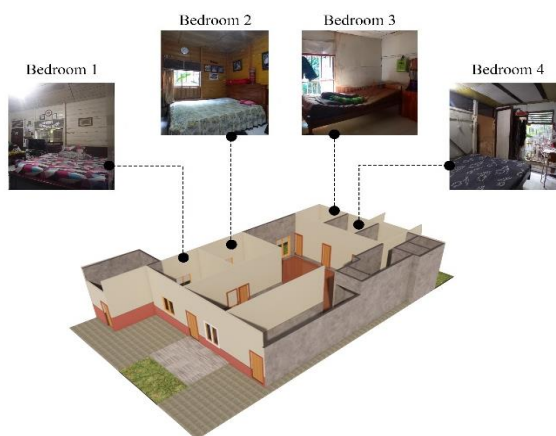
Furthermore, one of six findings [9] is that lighting should be designed according to user's satisfaction and various uses of space. This finding should be the main consideration in designing lighting in dwelling spaces in post-pandemic, especially daylight for sunbathing. Kurniasih and Pratama [10] proposed a window prototype for maximizing daylighting in order to sunbathe in a dwelling in the range of 10.00 am to 03.00 pm. This research resulted in the development of a prototype window that is intended to increase immunity

by providing human sunbathing space. The third prototype window is the opening on the roof of a building that has dimensions of 1.20 m x 0.83 m that provides the most natural light with a lighting intensity value of 8701 lx. It can be an architectural solution to increase the body's immunity against the Covid-19 virus by providing a multifunctional sunbed.

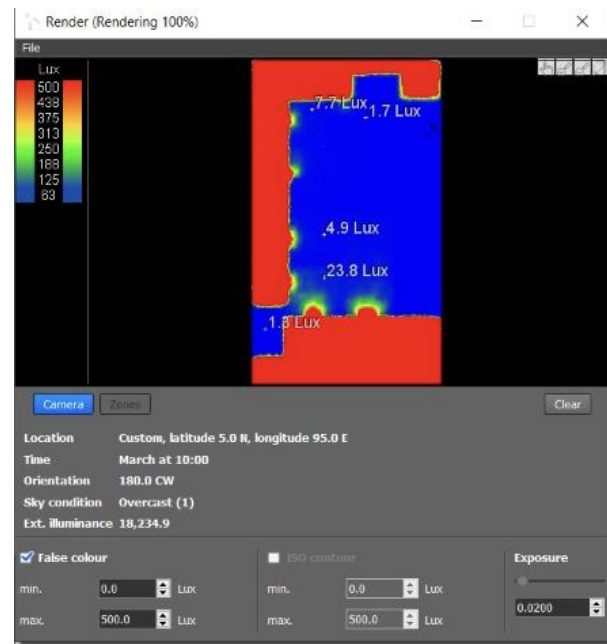
However, dwelling users in dense areas are struggling to be exposed to daylight in the right amount. As a case study, Maulizar's house located in Jalan Tongkol no. 22, Kampung Laksana, Banda Aceh, Indonesia (figure 1) is explored to find strategies and design of openings in order to get enough daylight in self-isolation space. The preliminary simulation in four bedrooms (figure 2) of this house shows that there is not enough natural lighting used for sunbathing in order to increase the immune system as self-isolation in dwelling (1.7, 4.9, 7.7, and 23.8 lux) (figure 3).



**Figure 1** Maulizar's house.



**Figure 2** Four bedrooms position in Maulizar's House.



**Figure 3** The preliminary daylight simulation in Maulizar's House on March 21st at 10.00 am.

Taking everything into account, this study aims to propose and explore the daylight strategies and design of self-isolation spaces of dwellings in densely populated areas.

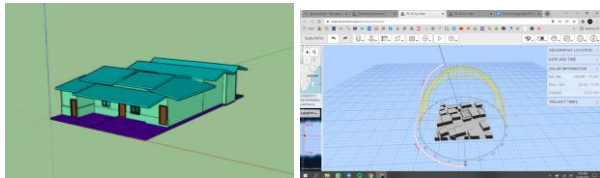
## 2. METHODS

Conducting the same method as Edytia et al. [11] to observe lighting, this computational study is employed to evaluate daylight exposure at a dwelling owned by Maulizar's house located in a densely populated area, Kampung Laksana, Banda Aceh. Existing 3D modeling, daylight analysis, and 3D exploration design software are utilized in this study. The existing dwelling is modeled using Google SketchUp and Autodesk Revit utilizing space dimension measurements by the Krisbow series 10106734 as a laser distance meter. Yokogawa series 3281A is used to record existing daylight illuminance both in dwelling and bedrooms as self-isolation space.

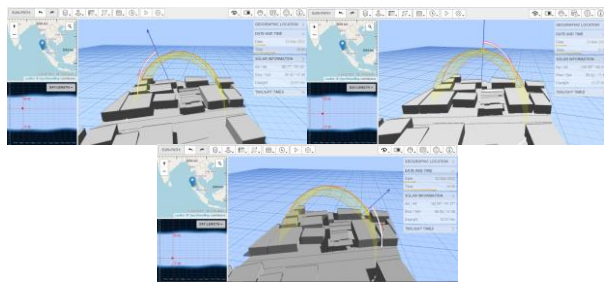
The daylight analysis employs Andrewmarsh PD: Dynamic Daylight for neighborhood scale and VELUX Daylight Visualizer 3 for dwelling and bedrooms at indoor scale. The data obtained are used to explore the position and size of openings which let the required and desired amount of daylight in particular time between 10:00 am and 03:00 pm along with sun position in the 21st of March, 21st of June, 21st of September, and 21st of December each year.

### 3. RESULTS AND DISCUSSION

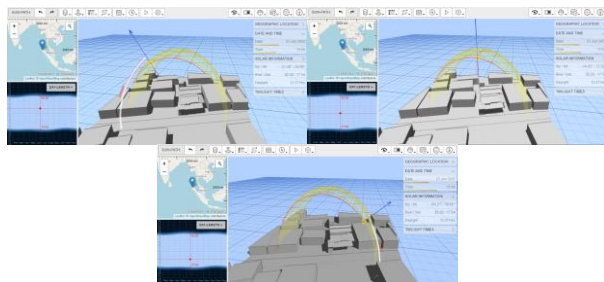
The simulation carried out after 3D modeling of the existing house and neighborhood scale (figure 4) is to see how the sun moves throughout the year towards the house. This simulation was employed through a website-based program, Andrewmarsh PD: Dynamic Daylight with variables at 10am, 12pm, and 3pm. The following are the simulation results for the four dates of the sun's movement in a year (figure 5-8).



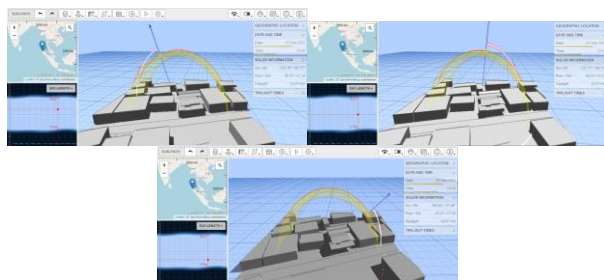
**Figure 4** 3D modeling of the dwelling (left) and setting modeling location in Andrewmarsh PD: Dynamic Daylight (right).



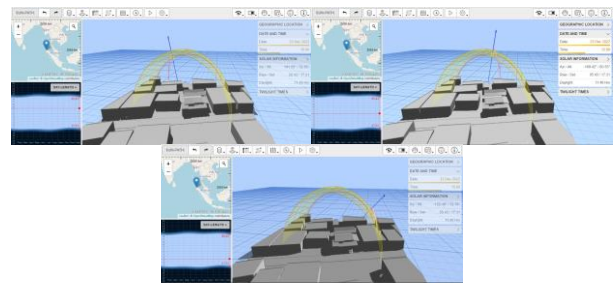
**Figure 5** Simulation I, March 21 at 10 am, 12 pm, 03 pm.



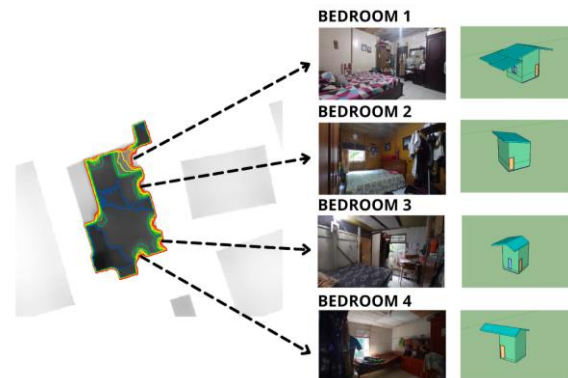
**Figure 6** Simulation II, June 21 at 10 am, 12 pm, 03 pm.



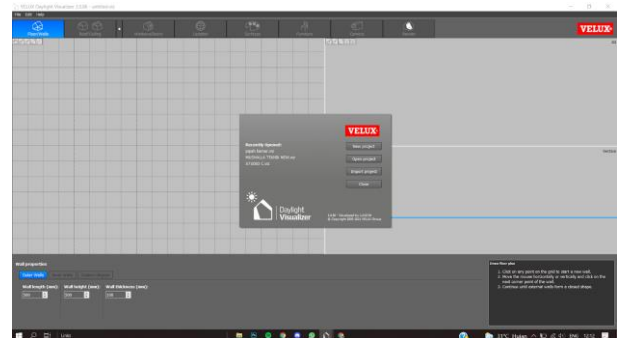
**Figure 7** Simulation III, September 21 at 10 am, 12 pm, 03 pm.



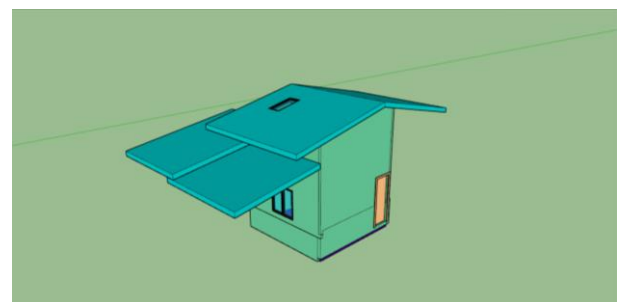
**Figure 8** Simulation IV, December 21 at 10 am, 12 pm, 03 pm.



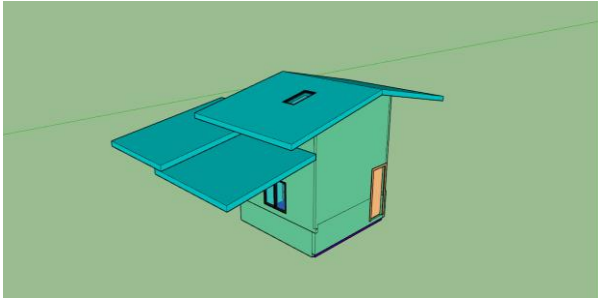
**Figure 9** Daylight exposure existing simulation employed by VELUX Daylight Visualizer 3.



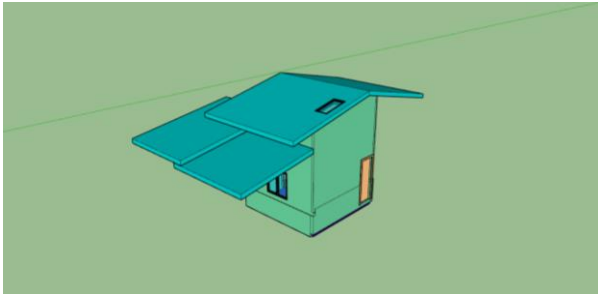
**Figure 10** VELUX Daylight Visualizer 3 interface.



**Figure 11** Type A of skylight (West) exploration model in the bedroom I.



**Figure 12** Type B of skylight (middle) exploration model in the bedroom I.

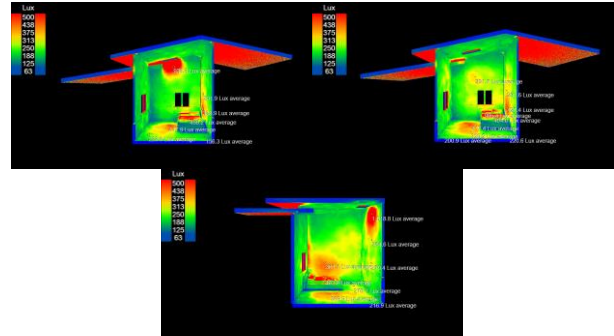


**Figure 13** Type C of skylight (East) exploration model in the bedroom I.

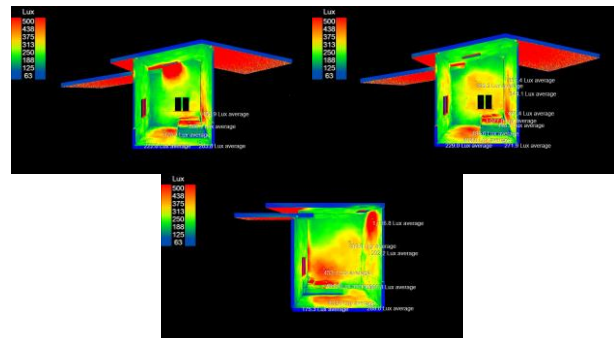
Based on the simulation results, initial data are obtained that room 1 gets more daylight exposure than the other three rooms due to its position against other buildings in the dwelling (figure 9).

The next results are the simulation of the placement of skylight openings in room 1 utilizing VELUX Daylight Visualizer 3 (figure 10) to let daylight as the best position for sunbathing. The exploration models are divided into three types according to the skylight's position (figure 11-13). Type A is an exploration model which has a skylight on the West side of the roof. While type B has a skylight in the middle, the type C model has a skylight on the East side.

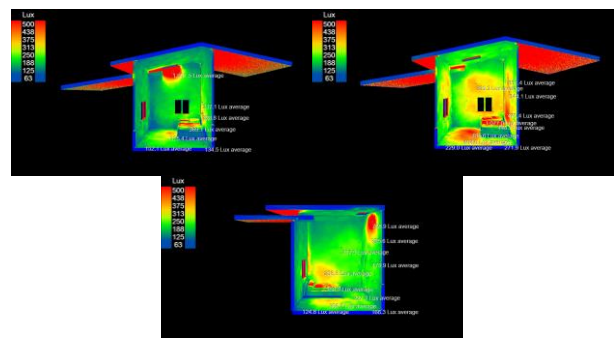
The best positions are those that allow a maximum daylight exposure for all three times, 10:00 am, 12:00 pm, and 03:00 pm throughout the year, and have exposure area coverage on the floor. The following is a simulation result of 3 model rooms with different skylights measuring 1,2 x 0.83 meters using the VELUX Daylight Visualizer 3.



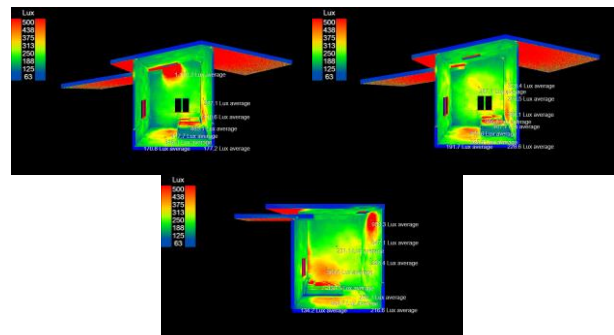
**Figure 14** Simulation I on March 21 at 10 am in type A (left), type B (middle), and type C (right).



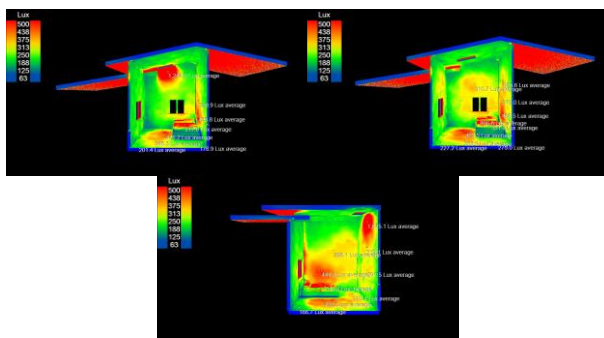
**Figure 15** Simulation I on March 21 at 12 pm in type A (left), type B (middle), and type C (right).



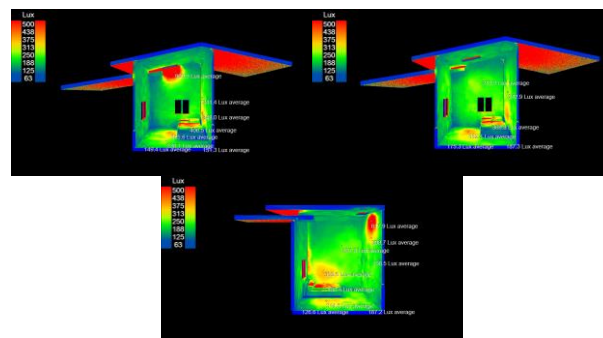
**Figure 16** Simulation I on March 21 at 03 pm in type A (left), type B (middle), and type C (right).



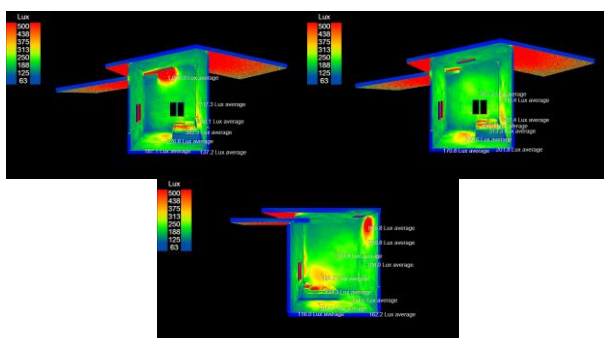
**Figure 17** Simulation II on June 21 at 10 am in type A (left), type B (middle), and type C (right).



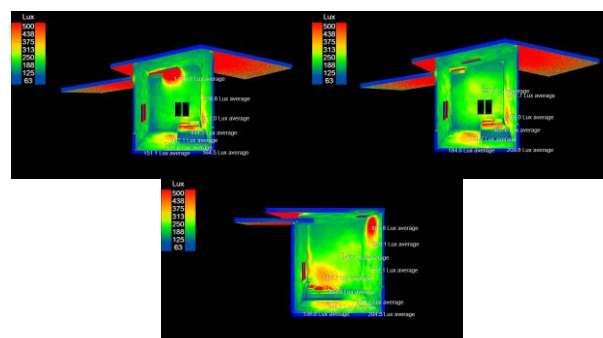
**Figure 18** Simulation II on June 21 at 12 pm in type A (left), type B (middle), and type C (right).



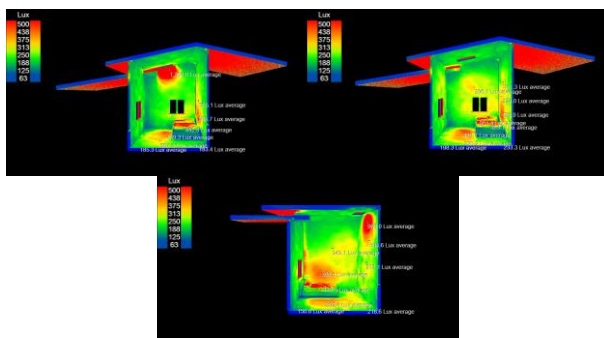
**Figure 22** Simulation III on September 21 at 03 pm in type A (left), type B (middle), and type C (right).



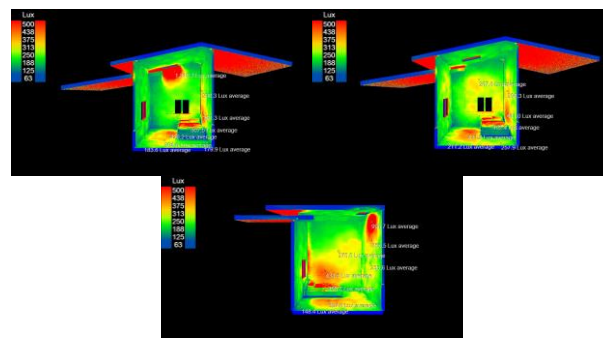
**Figure 19** Simulation II on June 21 at 03 pm in type A (left), type B (middle), and type C (right).



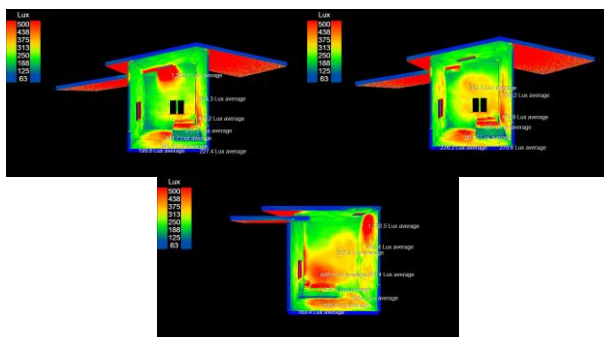
**Figure 23** Simulation IV on December 21 at 10 am in type A (left), type B (middle), and type C (right).



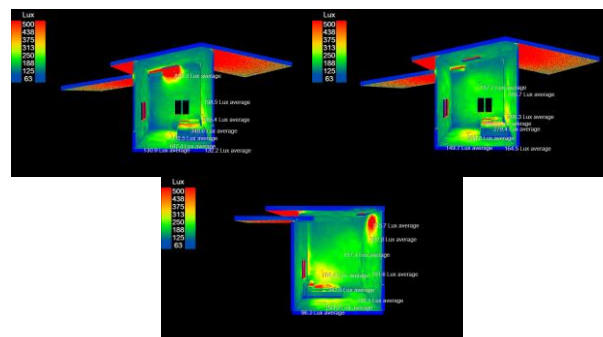
**Figure 20** Simulation III on September 21 at 10 am in type A (left), type B (middle), and type C (right).



**Figure 24** Simulation IV on December 21 at 12 pm in type A (left), type B (middle), and type C (right).



**Figure 21** Simulation III on September 21 at 12 pm in type A (left), type B (middle), and type C (right).



**Figure 25** Simulation IV on December 21 at 03 pm in type A (left), type B (middle), and type C (right).

**Table 1.** The average of daylight exposure simulation (Lux)

Simulation	Type A	Type B	Type C
I	502,6	943,8	438,8
II	461,5	844,4	455,1
III	503,6	642,5	505,2
IV	433,5	520,6	441,8
Average	475,3	737,83	460,23

**Table 2.** Daylight coverage simulation index

Simulation	Type A	Type B	Type C
I	2	3	1
II	1	3	2
III	1	3	2
IV	1	3	2

Based on these results, the best skylight position is type B, in the middle, due to the highest floor exposure (737,83 lux) and coverage (scale 3) throughout the year.

#### 4. CONCLUSION

The preliminary simulation in four bedrooms shows that there is not enough natural lighting used for sunbathing in order to increase the immune system as self-isolation in dwelling (1.7, 4.9, 7.7, and 23.8 lux).

Through daylight simulation by Andrewmarsh PD:Dynamic Daylight analysing in neighborhood scale and VELUX Daylight Visualizer 3 analysing indoor scale, four times in a year and three times in a day, there are design recommendation to choose the best bedroom as self-isolation space for sunbathing and the position of the skylight.

This study is open to further research by combining the results of behavioral exploration of dwellers to determine the appropriate self-isolation space with the programming of dwelling.

#### ACKNOWLEDGMENT

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