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Daylighting perception in residential spaces according to users

Percepção da iluminação natural no ambiente residencial de acordo com os usuários

Percepción de la iluminación natural en el entorno residencial según los usuarios

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Abstract

In Brazil, both NBR 15.575:2013 and NBR 15.215:2005 are in the process of being revised, including new evaluation indexes related to human preferences. Thus, this study aimed to understand the perception of occupants in the use of residential space to support eventual normatization indications. The methodology consisted of conducting an online questionnaire, applied in 2020, with 542 valid responses from all over the country. The Likert scale was used to analyze the results. The results showed that residences located in dense regions had the worst weighted averages in the evaluation of the quality of daylight and that the presence of larger openings for lighting, in turn, generated better results. In the kitchens, it was found that the indirect lighting by the service area, as well as the kitchen layout affect the perception of the availability of daylight of the space, this being the second environment indicated as being of higher priority for good daylighting. It was also found that there is a demand for better daylighting of the bathrooms. Generally speaking, the results reveal a correlation between factors that influence the daylight availability and the perception of users, and its consideration is considered of paramount importance for the adequate definition of metrics of the Brazilian regulations.

Keywords: Daylighting; Environmental perception; Design quality; Standardization.

Resumo

No Brasil, tanto a NBR 15.575 quanto a NBR 15.215 estão em processo de revisão na área de iluminação natural, passando a incluir novos índices de avaliação relacionados às preferências humanas. Sendo assim, este estudo visou compreender, a percepção de usuários na utilização do espaço residencial de forma a embasar eventuais dispositivos de normatização. A metodologia consistiu na realização de questionário on-line, aplicado em 2020, contando com 542 respostas válidas de todo o território nacional. Para análise de resultados foi usada a escala Likert. Os resultados mostraram que residências localizadas em regiões adensadas tiveram as piores médias ponderadas na avaliação da qualidade da iluminação natural e que a presença de maiores aberturas para iluminação, por sua vez, gerou melhores resultados. Nas cozinhas, constatou-se que a iluminação indireta pela área de serviço, assim como o seu layout afetam a percepção da disponibilidade de luz natural no interior daquele ambiente, sendo indicado como o segundo de maior prioridade para uma boa iluminação natural. Verificou-se ainda que há demanda para melhor iluminação natural dos banheiros. De modo geral os resultados revelam correlação entre fatores que influenciam na disponibilidade de luz natural e a percepção dos usuários, podendo esta percepção ser usada no estabelecimento de normativas.

Palavras-chave: Iluminação natural; Percepção ambiental; Qualidade do projeto; Normatização.

Resumen

En Brasil, tanto la NBR 15.575:2013 como la NBR 15.215:2005 están en proceso de revisión, incluyendo nuevos índices de evaluación relacionados con las preferencias humanas. Por lo tanto, este estudio tuvo como objetivo comprender la percepción de los usuários en el uso del espacio residencial para apoyar eventuales dispositivos de normatización. La metodología consistió en la realización de un cuestionario online, aplicado en 2020, con 542 respuestas válidas de todo el país. Se utilizó la escala Likert para analizar los resultados. Los resultados mostraron que las residencias ubicadas en regiones densas tuvieron los peores promedios ponderados en la evaluación de la calidad de la luz natural y que la presencia de aberturas más grandes para la iluminación, a su vez, generó mejores resultados. En las cocinas, se encontró que la iluminación indirecta por el área de servicio, así como el diseño de la cocina afectan la percepción de la disponibilidad de luz natural dentro del espacio, siendo este el segundo ambiente indicado como de mayor prioridad para una buena iluminación natural. Se ha verificado que hay necesidad de mejor iluminación natural para los baños. De manera geral Los resultados revelan una correlación entre los factores que influyen en la disponibilidad de luz natural y la percepción de los usuarios, y su consideración es de suma importancia para la dirección adecuada en el establecimiento de métricas de las normas brasileñas.

Palabras-clave: Iluminación natural; Percepción ambiental; Calidad del proyecto; Estandarización.

1 Introduction

Daylight is the main source of light to ensure lighting needs in buildings (Cen, 2018b, p. 6), constituting a fundamental component of architecture (Morales-Bravo; Navarrete-Hernandez, 2022). In this sense, daylighting is preferred by users to illuminate indoor spaces (Cen, 2018b, p. 6), and visual comfort perception is guided by the relationship between quantitative and qualitative aspects of daylight (Jamrozik *et al*. 2019). Fleming *et al*. (2018) and Lundgren (2013) also verified the participation of daylight in the perceived value of real estate, reflecting on the decision to buy and rent housing.

According to the European standard *EN* 12.665, the visual environment provides a subjective condition of visual well-being to the individual (Cen, 2018a), in which the quality of the internal space significantly affects the occupants' performance in terms of physiological, behavioral, and cognitive aspects (Wang *et al*., 2021). Parallel to this, human beings spend about 80 to 90% of their time inside buildings, that is, immersed in artificially lit spaces (Seo *et al.*, 2021), a dynamic that was enhanced by the Covid-19 pandemic period, since, due to social isolation, all activities began to be carried out in the residential space (Santiago *et al*., 2021).

From this perspective, there was a change in the use of homes through the expansion of the visual activities performed, given that these became places of study and work – through the *home office regime* –, thus modifying the users' perception of residential visual spaces. This is due, above all, to the improvisation of spaces for the exercise of working tasks, which, in general, does not guarantee adequate conditions for the user's visual comfort (Amorim *et al*., 2021).

Occupancy and interactions with devices in the building are influenced by environment-related, time-related, and random variables. Environmental variables include aspects related to solar orientation, building envelope characteristics, building *layout* and local climate, among others. Time-related variables comprise the occupants' routine, influenced by the time of day and the day of the week. Psychological variables, on the other hand, are rarely considered in studies of occupant behavior due to difficulties associated with their quantifying and monitoring (Balvedi; Ghisi; Lamberts, 2018).

However, in the scientific community, it is always desirable to correlate different objective measures with subjective responses. This helps not only to better understand how subjective evaluations of the daylit environment are affected by different characteristics of daylight, but also to develop measures and criteria for building classification and design (Wang *et al*. 2020). In this sense, the questionnaires application can be a useful tool in understanding user preferences.

Peng Xue *et al*. (2014) after applying questionnaires to 340 respondents, pointed out that satisfaction with daylighting in homes is influenced by several variables, such as the uniformity perception, external obstructions, and solar orientation. They also point out that visual comfort is a function of both users' behavior patterns and daylighting conditions.

Eriksson *et al*. (2019) point that correlation between simulation, measurement and user satisfaction allows a unique analysis of users' preference for environments with good daylighting, highlighting in this scenario, the kitchen.

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Eriksson *et al*. (2019) saw in their study that the correlation between simulation, measurement and user satisfaction allows a unique analysis of users' preference for spaces with good daylighting, highlighting in this scenario, the kitchen.

With the advancement of studies in the area, from 2018, the daylighting requirements of ABNT NBR 15.575:2013 for residential buildings entered a revision process considering the change in calculation procedures to adopt climate-based simulation metrics, with the evaluation to be made for the entire year, based on climate files. This part of the standard is in the final process of approval.

In 2019, ABNT NBR 15.215:2005 part 3 also entered a revision process which now adds, not only of daylight availability evaluation based on the climate for non-residential buildings, but criteria also related to the quality of view out, daylight glare assessment, criteria for maximum and minimum insolation in indoor spaces and consideration of circadian light. This standard deals with both residential and non-residential spaces. This part of the standard is expected to go into public consultation in the 1st half of 2024.

Thus, this research was carried out seeking to understand the user's preferences and their relationship with the residential daylit space in order to contribute to the final discussions on the standardization texts related to residential buildings.

2 Metodology

The methodology of this study consisted of raising issues related to the daylighting of residential spaces that could be investigated through user preferences.

A questionnaire with 82 questions was elaborated divided into 8 sections, the first section presenting demographic questions in order to characterize the respondent (age, gender, education and monthly income), and the place of residence (city, type of housing and neighborhood density). Sections 2 to 7 are composed with questions directed to residential spaces: living room, bedrooms, kitchen, laundry area, bathrooms, and

common use area (for residents in multifamily buildings). The questions covered the characteristics of the house space, the activities performed in the space by the user and the daylight perception in each room. Questions were also asked about the factors that interfere with the daylight availability, such as surroundings, openings, and glass types, allowing the correlation between these answers and the residential daylight quality. The last section presented questions about the level of importance and priority of daylighting and the house use before and during the Covid-19 pandemic.

In the questions about the types of openings, illustrations or photos were presented for better understanding, as is the case of the question about the glass type, using the images that can be seen in Figure 1.

Figure 1: Ilustration of the types of glazing used in the space opening.

The questionnaire was applied to researchers from LABCON-UFMG as a pre-test to assess their clarity and to determine the average response time. The response time to the questionnaire was estimated to be approximately 10 minutes, and most of the questions were multiple-choice. After this stage, the application of the questionnaire took place during the period of July and August 2020 - a time when Brazil was going through the Covid-19 pandemic, which began in March 2020 - through an online questionary applied through Google Forms, in which the *link* was directed both by email and via messaging application seeking to cover the entire national territory. The questionnaire was answered anonymously, voluntarily and without collecting personal data, such as name and/or identity, and there was no contact between researchers and respondents at any time. Respondents were required to read a TLE and agree to it before accessing the questionnaire. In this way, the privacy of the information provided was guaranteed by the responsible researchers. This complies with the Brazilian Article 1 of CNS Resolution No. 510 regarding research ethics.

The aim of the questionnaire was to investigate the perception of users regarding the daylighting quality of their homes. To this end, questions related to the daylight quality and the importance of daylighting were asked, which followed the response criterion according to a 5-point Likert scale - a research scale used to measure opinions, perceptions and behaviors through the comparison of binary questions and a correlation with numerical values. Thus, the answers obtained were evaluated from +2 (excellent, always, or very important performance) to -2 (very poor performance, never or not important) with 0 indicating neutral performance, frequency or importance. To portray the users' preference, a weighted average of the answers obtained in each item was used.

During data processing, it was perceived the need to separate some answers into two types of residence: house and apartment, enabling a better visualization of the users'

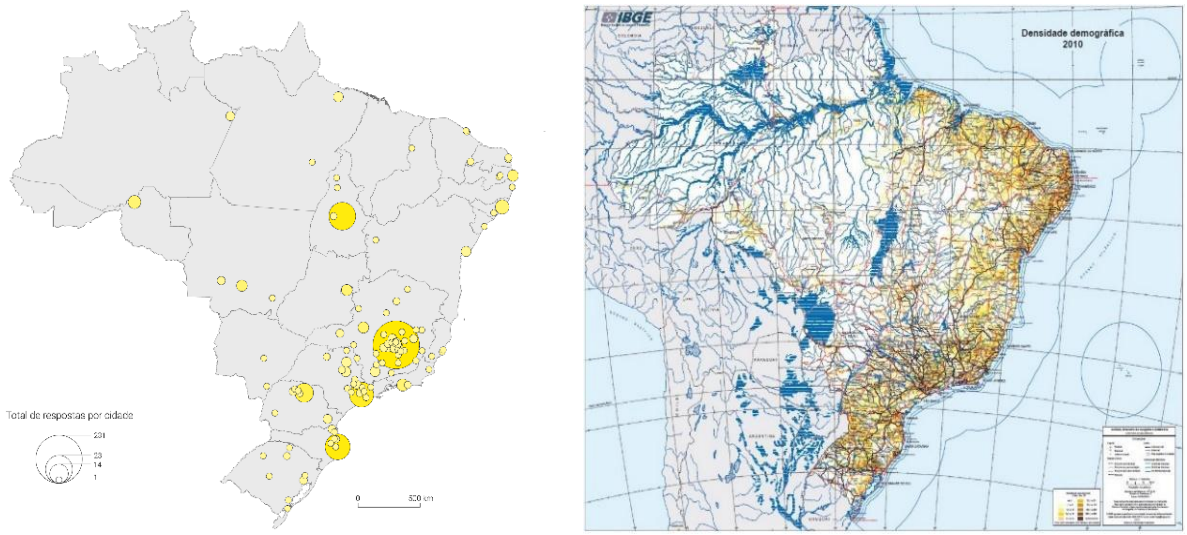
perception in each typology. The answers were arranged in graphs in which it is possible to see, at the same time, the average response of the Likert Scale, as well as the distribution of preferences.

Finally, a combined analysis of the responses and preference levels obtained was made to generate possible recommendations for technical standardization, currently in the process of revision.

3 Results

The application of the questionnaire resulted in a total of 601 responses. After verifying repeated responses during data processing, this number was reduced to 542 valid responses, distributed throughout the Brazilian territory. In addition, it was noted that the regions with the highest number of valid responses corresponded to the Brazilian regions with the highest population density (Figure 2).

Figure 2: Distribution of responses in the Brazilian territory and Brazilian demographic density



Source: IBGE (2021).

The proposed revision of the NBR 15.575-1 standard establishes a division of the national territory into three latitude bands (Figure 3). By determining the latitudes of the cities, it was noticed that the largest portion of the respondents was in Range 2 (61%), this range includes cities such as Belo Horizonte, Palmas and Brasília. This was followed by Range 3 with 29%, represented by São Paulo, Florianópolis and Rio de Janeiro. And 9% of the respondents are from Band 1, which have Maceió, Porto Velho and Belém as the main cities represented. However, it was not possible to identify the latitude range of the geographic zoning of 1% of the answers, since the respondent's city was not informed in the questionnaire.

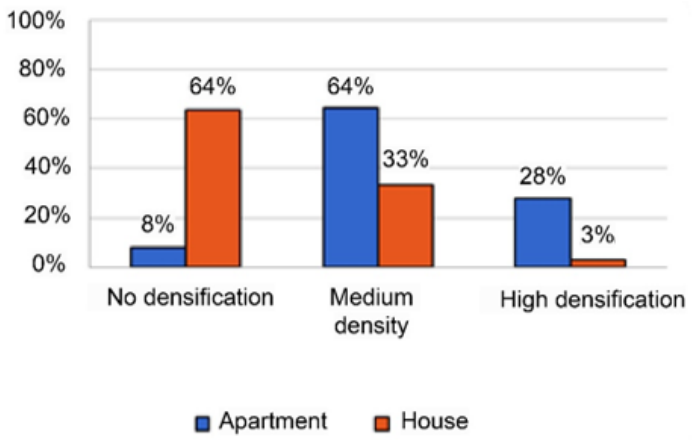
Figure 3: Geographic zoning by latitude proposed by NBR 15.575-1.

Source: ABNT (2020).

Regarding gender, 74% declared themselves as females and 26% males, and 81% of the respondents were aged between 18 and 54 years. Regarding the population projection data for the year 2020 from the Brazilian Institute of Geography and Statistics (IBGE), 73% of the national population is in the age group of 20 to 54 years, being composed of 52% women and 48% men. In addition to gender and age group, the questionnaire also presented results on education levels and monthly family income. Of the respondents, 56% have a postgraduate degree, 33% have a family income of 3 to 8 minimum wages and 30% from 8 to 15 minimum wages.

Considering all valid answers, apartment-type housing units were the most frequent typology, representing 59%, while houses, 41%. Most of the interviewees answered that the neighborhood of their residence is characterized as medium dense, totaling 52%. The non-dense environment corresponded to 31% and the high-density area to 18% of the valid responses. Thus, correlating these two results (Figure 4), it is interesting to observe that 64% of the houses are located in regions without density, while apartments are the majority in regions with medium density, about 64%. On the other hand, the high-density region has a predominance of apartment buildings, totaling 28%.

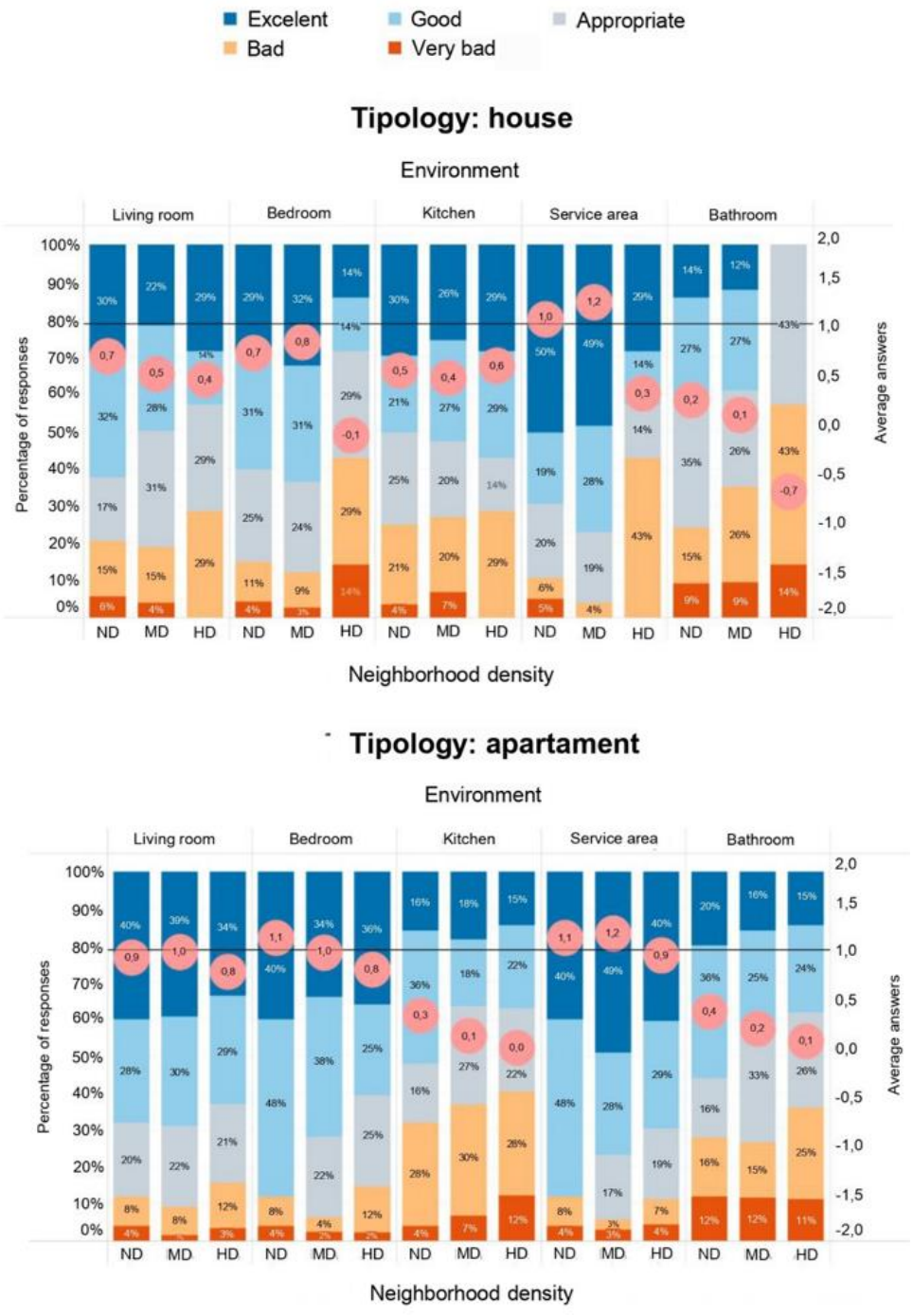
Figure 4: Distribution of housing typologies by neighborhood density.



According to the neighborhood density model, two graphs were prepared with the percentage values of the responses and the weighted average of the daylight quality per room for the two types of housing (Figure 5). In all graphs, the value 1 was marked with a black line, and considered as "good performance"".

It can be seen in Figure 5 that, in general, all spaces, both for apartments and houses, located in regions of high density, presented lower daylight quality compared to the other 2 types of densities, except for the kitchen of the house typology, which in a situation of high density presented better performance than in the other 2 situations. Regarding the type of housing, apartments presented better results when compared to houses, except for the kitchens, which obtained better results in houses.

Figure 5: Percentage of responses and weighted average of daylight quality per room according to neighborhood density.



*ND – no densification; MD – medium density; HD - high densification

The spaces that presented the best results for the houses were the service area, the living room, the kitchen, the bedroom, and the bathroom, in that order. As for the apartments, they were the service area, the bedroom, the living room, the bathroom, and the kitchen. According to the respondents' perception, the service area was the space with the best daylighting in both cases. The fact that the kitchen presented the best results in the houses was mainly due to the higher presence of windows directly daylighting this space. On the other hand, the apartments had a higher percentage of indirect daylighting of kitchens, usually daylit through service areas (Figure 6). It is also important to analyze that the kitchen model interferes with the perceived daylight quality: the American model - open to the living room - contributes to greater daylight availability, as it receives light from the living room. The closed kitchen, on the other hand, has a daylight contribution of its own window. This last model is predominant in both types of housing, 73% of the responses in apartments and 60% in houses. In addition, the American kitchen model presents a higher occurrence in the house typology (Figure 7).

Figure 6: Kitchen opening type according to residence type.

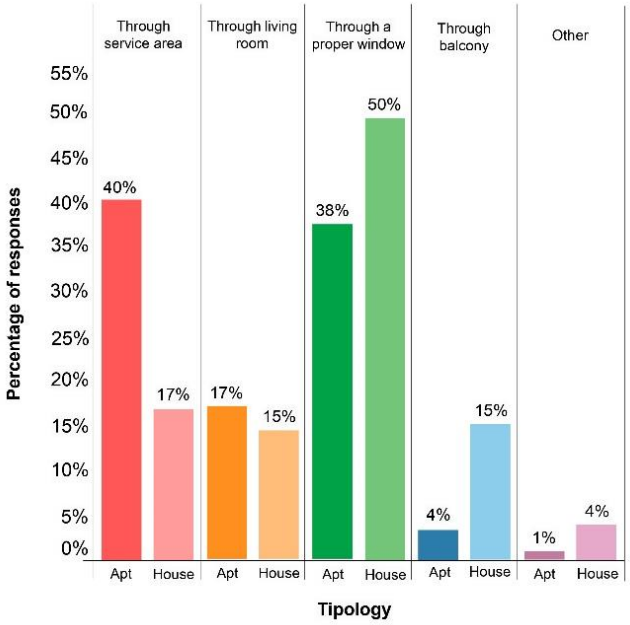
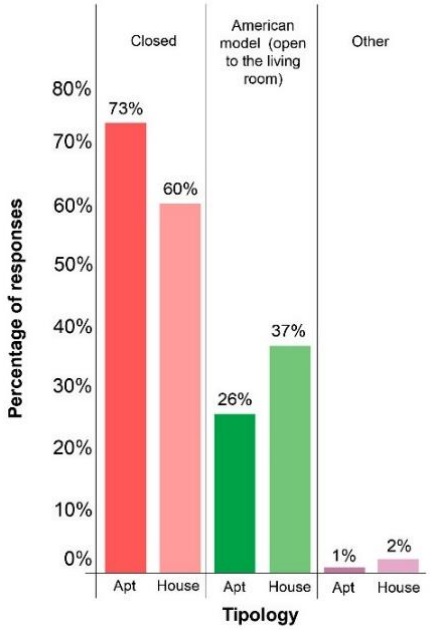


Figure 7: Kitchen model according to residence type.



The relationship between the window type and the kitchen type for the respondents' daylight perception can be seen in Figures 8 and 9. For apartment dwellers, daylighting through a proper window presents better daylighting quality than other opening types. For home dwellers, the kitchen daylighting from a balcony or a living room present better quality, with direct daylighting through a proper window coming in third place. In both building types, daylighting through the service area obtained the lower quality results. Regarding the kitchen type, both for apartments and houses, the American model, open to the living room, was the one that presented the best respondent's perception when compared to the results of the closed kitchen.

Figure 8: Percentage of responses and weighted average on daylight quality in relation to the kitchen opening type.

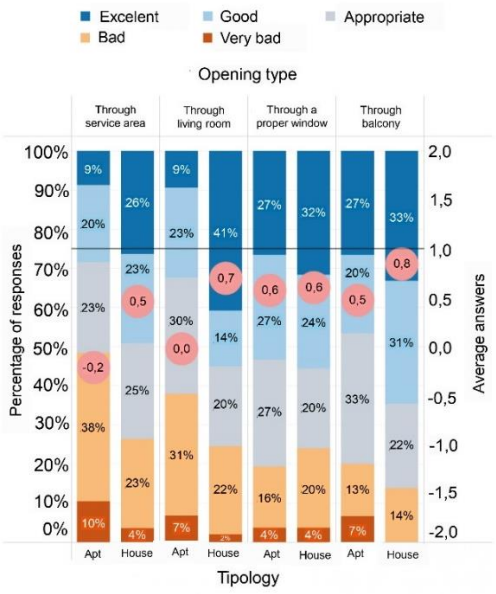
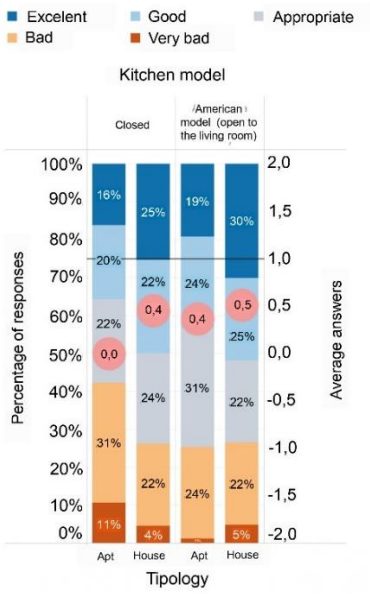


Figure 9: Percentage of responses and weighted average on daylight quality in relation to the kitchen model.



One of the determining factors for the daylight availability indoors is the external opening type. In this sense, the questionnaire asked about the external openings of living rooms and bedrooms. In the living room, the "window" type prevailed, with 62% - a percentage obtained by adding the models "window with conventional sill" and "window with lower sill". It was also possible to find, in 31% of the answers, the daylighting of the room being carried out through a "door that opens onto a covered porch". In the bedrooms, the "window" model was predominant, with 96%, with the "window with sliding glass leaves" model standing out, with 50% of the answers. In sequence, the "sliding shutter window" presented 32% and the "window with integrated shutter" 10% of the responses. The most commonly used type of glass in these two spaces was the clear glass, in more than 80% of the sample.

In living rooms, windows with low sills and glass doors presented the best results in terms of the daylight perception (Figure 10). Parallel to this, the presence of a balcony with a masonry sill was the type of opening that presented the worst results. For the bedrooms (Figure 11), the "integrated shutter" model was the respondents' preference for the daylight perception. This model allows greater control by the user, maintaining, when desired, a good use of daylight. The "sliding shutter" model equaled the preference of the respondents living in apartments, along with the "glass window" model. In the house typology, the "glass window" had a better result than the "sliding shutter" model. The "glass door" was not very representative (only 2% of the answers), but it is worth mentioning that, when present, it stands out with good results for the daylight perception in the space, reinforcing the justification that users prefer models of openings with a lower windowsill.

The users' preference was verified in relation to the glazing type (Figures 12 and 13) of living rooms and bedrooms. For the living room, "mirrored/solar controlled" glazing showed better results, even than clear glass. This is due to the opening model corresponding to this glass having a lower sill - a preference discussed earlier. However, its representativeness is very low, with only 1% of valid answers. The clear glass, in sequence,

presents the best results for houses, equaling, for apartments, the green/blue glass. Tinted glass is the type of glass that has the lowest quality results. In the bedrooms of the apartment type, green/blue glass was the one that presented the best quality perception results, followed by smoked.

Figure 10: Percentage of responses and weighted average on daylight quality in relation to the type of living room opening.

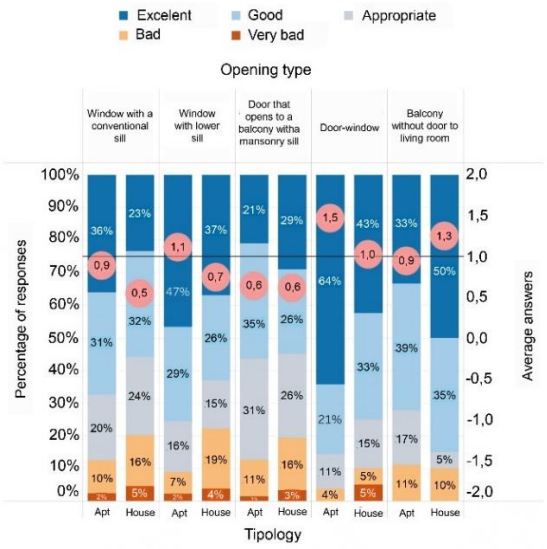


Figure 11: Percentage of responses and weighted average on daylight quality in relation to the type of opening in the bedroom.

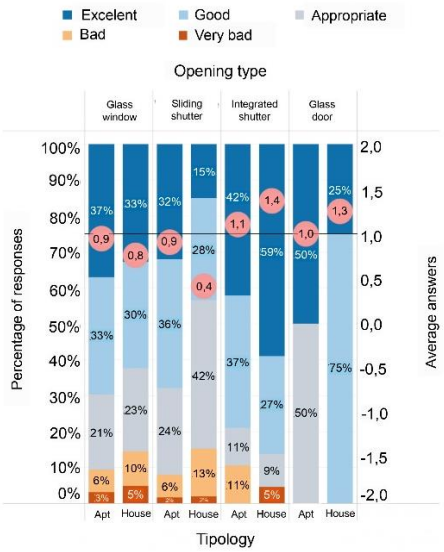


Figure 12: Percentage of responses and weighted average on daylight quality in relation to the glazing type of living room spaces.

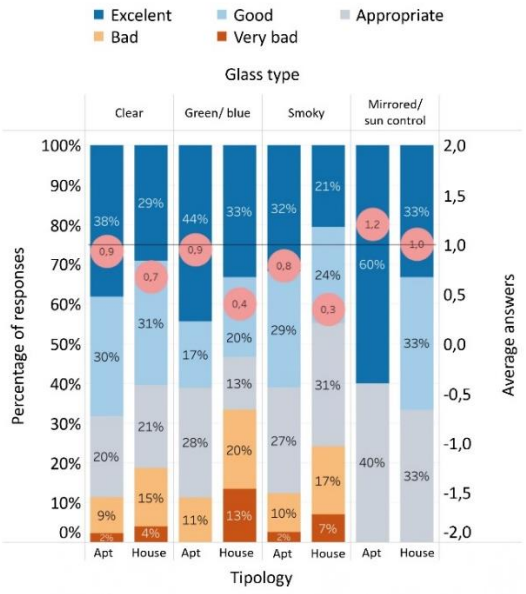
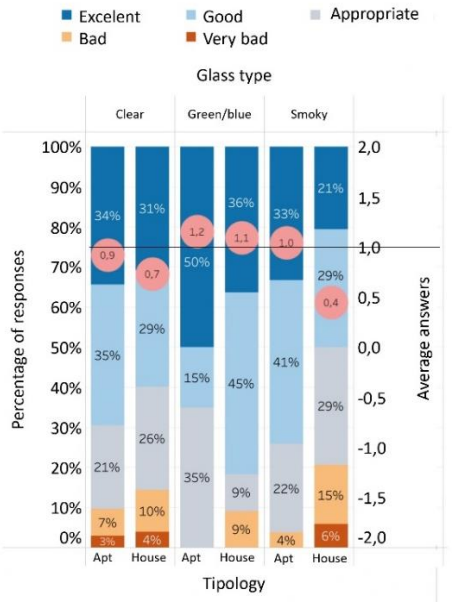


Figure 13: Percentage of responses and weighted average on daylight quality in relation to the glazing of the bedroom spaces.



The influence of the building surroundings is another determining factor for the daylight availability in the indoor space. Thus, the questionnaire asked about surrounding density in front of the living room and the bedroom openings. The predominant answer, for both spaces, was that there is no built density in front of the bedroom window, with 51% of the answers. In the living room, the second most selected option corresponds to a high density, with 19% of the valid answers. In the bedrooms, there was a tie between the high density and the surroundings with a boundary wall near the window, corresponding to 17% of the answers.

In view of this, the influence of the surroundings in front of the opening was compared with the daylight perception of the space (Figures 14 and 15) and it was noticed that this influence is significant in the perception of the daylight availability in the space by the user. In all situations, the best results were found when there is no presence of the external surroundings in front of the openings. In the worst-case scenario however, for living rooms in apartments, the lower daylighting quality is found when the surroundings are considered dense, while in houses, the worst-case scenario is presented when there is a boundary external wall near the opening. For dormitories, the situation is reversed. It is interesting to observe, then, that the obstruction of the surroundings, occurring at height or in proximity, impairs the user perception of the daylight presence in the space.

Figure 14: Percentage of responses and weighted average on daylight quality in relation to the surroundings in front of the living room opening.

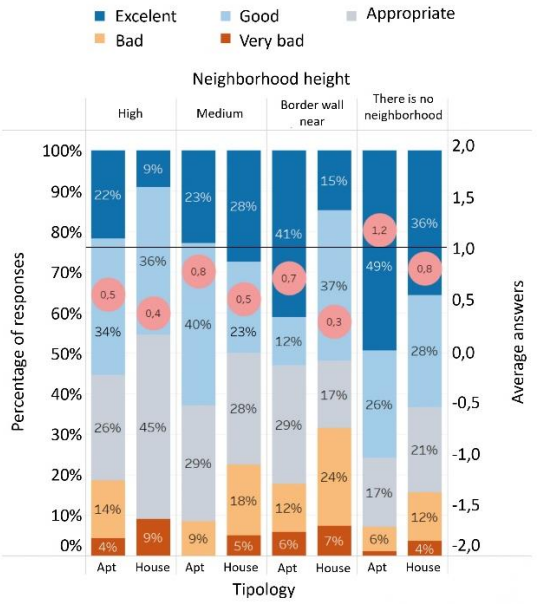
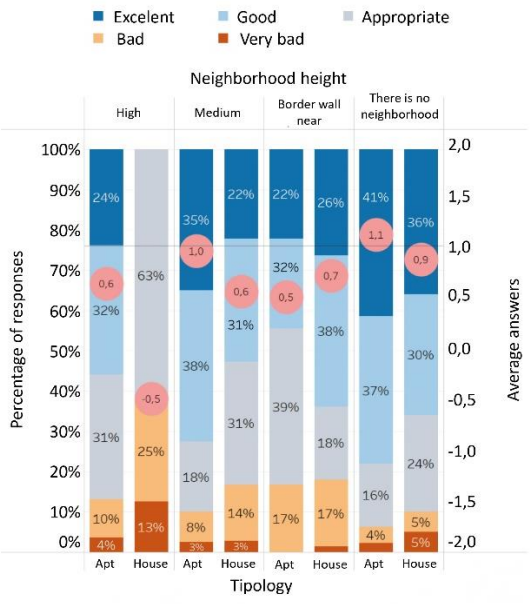


Figure 15: Percentage of responses and weighted average on the daylight quality in relation to the surroundings in front of the bedroom opening.



The visual activities performed during the day by the users were raised for the living room and the dormitory. In the living room, 60% of the answers corresponded to activities such as watching TV, eating meals, and resting; however, this does not exclude activities that require a higher level of illuminance, such as reading, working and studying, which correspond to 38% of the answers. In the dormitory, 32% answered that they rest and watch TV, and for more demanding visual tasks - writing, working, reading, and studying - the percentage was 51%.

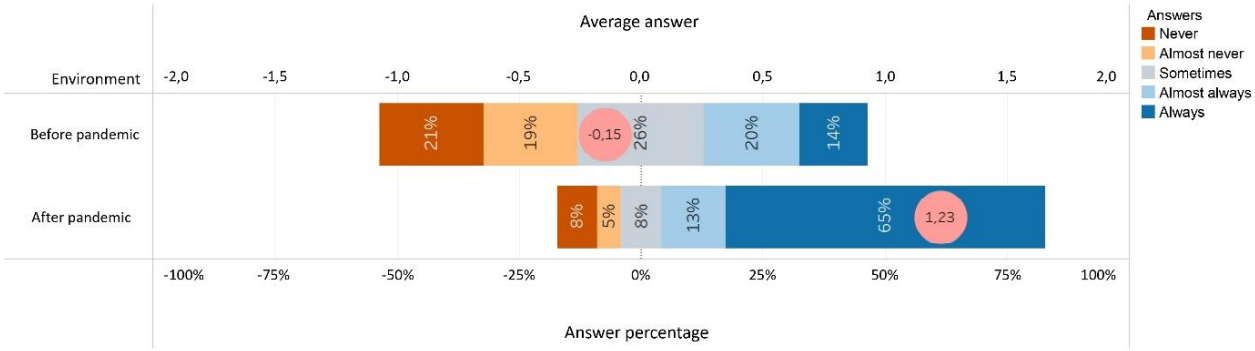
Considering the application of the questionnaire during the Covid-19 pandemic period, when social isolation was maintained, the usage number of hours of the living room, bedrooms, and kitchen before and during this period were questioned. the weighted average result, presented in Table 1, revealed a considerable increase in the time of use of these spaces. This result reinforces the importance of providing daylighting comfort for the new work activities that are being more inserted in the residential unit.

Table 1: Hours of use of spaces before and during the pandemic.

	Before the COVID19 pandemic (hours)	During the COVID19 pandemic (hours)
Living room	2h26	4h24
Bedrooms	3h01	4h50
Kitchen	2h10	3h01

It is observed that there was a significant increase in home office activities during the Covid-19 pandemic (Figure 16). Prior to this period, respondents worked from home sometimes, while during the pandemic, most respondents reported that they were working from home daily. Of the spaces used for home-office activities, the bedroom had the highest percentage of responses, with 32%, followed by the office with 29% and the living room, with 27%. These three spaces accounted for 88% of the responses.

Figure 16: Percentage of responses and weighted average on the frequency of home-office use before and during the pandemic.



It is also possible to observe the respondent's perception of the daylight quality in relation to their residence in Figures 17 and 18. The following questions were asked: "Without turning on the lamps, how is the daylighting in the space?" and "Do you turn on the lamps to perform any activity in the space during the day?". These questions complement each other and prove each other's answers. The service areas were considered to be the best daylit space, followed by bedrooms and the living rooms. Kitchens and bathrooms had a neutral daylighting quality perception. Regarding the electric lighting during the day to carry out activity in the space, the answers showed that the better the daylighting of the spaces, the lower the probability of turning on the electric lighting during the day, with bathrooms and kitchens being the places where electric lighting is used more frequently.

Figure 17: Percentage of responses and weighted average of daylight quality by room, without turning lighting on.

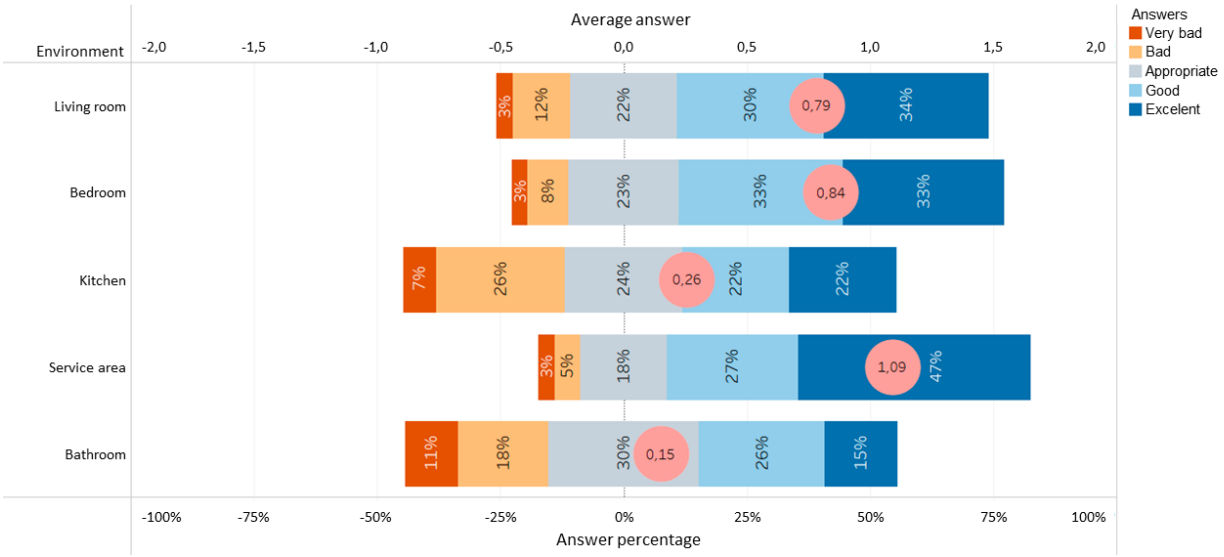
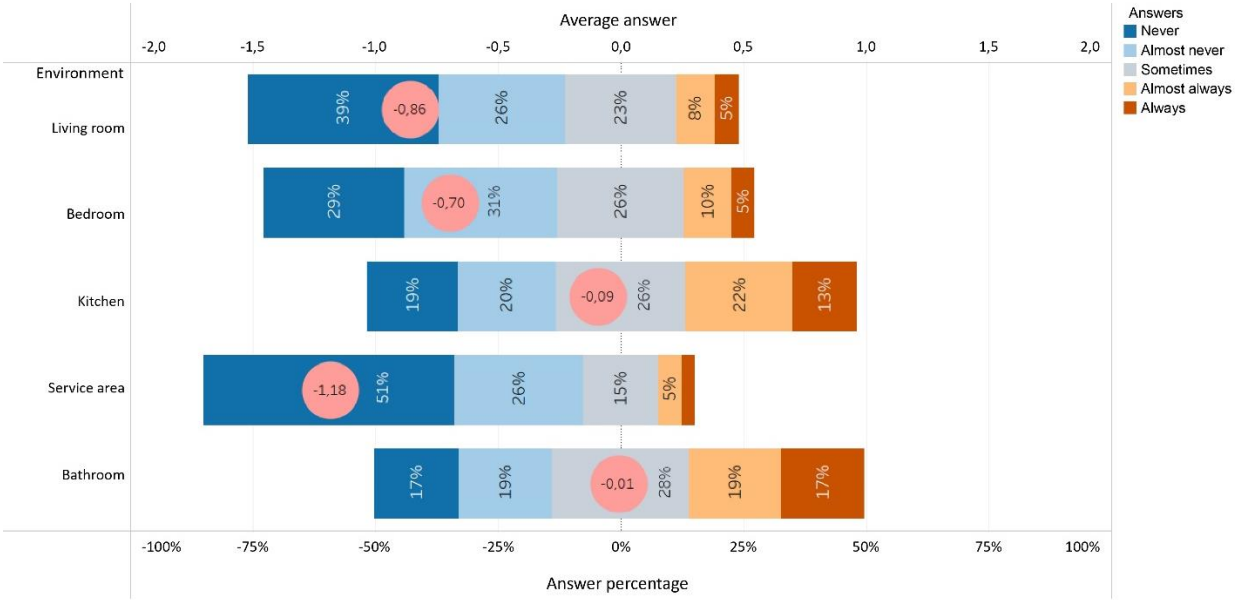
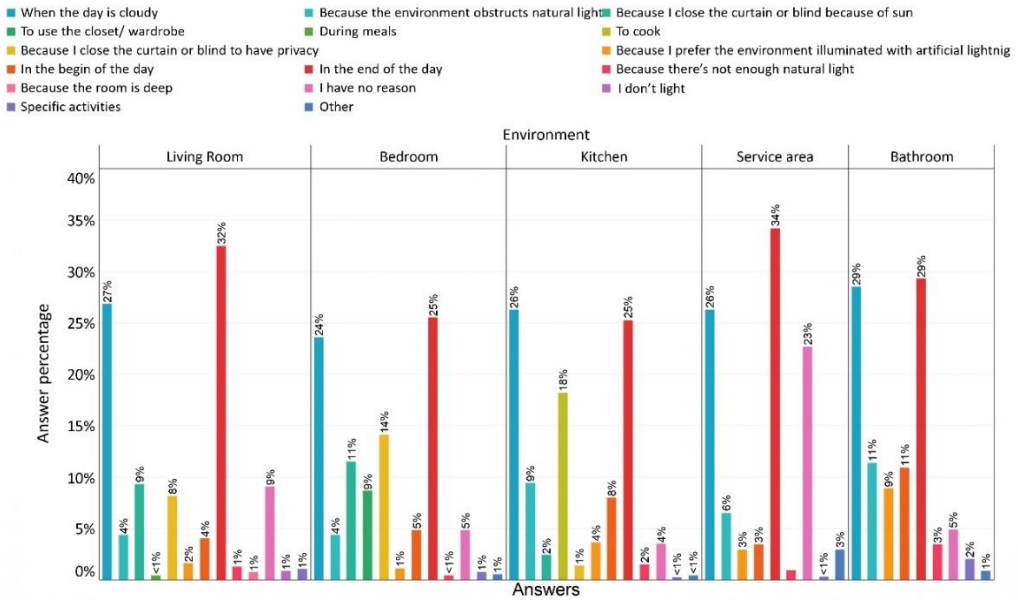


Figure 18: Percentage of responses and weighted average of the frequency of use electric lighting during the day by room.



The respondents were asked the reasons that lead them to turn on the light during the day in the space, and the two main ones, for all spaces, are "At the end of the day" and "When the day is cloudy" (Figure 19). These reasons demonstrate that the reduction of external daylight directly influences the perception of light quality in the internal space. There are also reasons related to the daylight obstruction by the surroundings, glare - for this reason, the curtain or blinds are closed - and specific activities of the space, such as cooking, using the wardrobe and during meals, the last two indicating a need for privacy.

Figure 19: Percentage of responses about the reasons for the use of electric lighting during the day by space.



The questionnaire also assessed the importance level of good daylighting, the presence of sunlight and good electric lighting for each room of the residence, including the collective areas of multi-family residential buildings, when they exist (Figure 22). Most respondents considered it very important that all rooms in the residence have good daylighting, with greater importance, however, in the living rooms and kitchens, followed by bedrooms and service areas, bathrooms having a slightly lower importance (Figure 20). Regarding the importance of the presence of sunlight, it was considered more important in the service area and in the dormitories. On the other hand, good electric lighting was considered more important in spaces considered less illuminated as previously shown in Figures 5 and 6: bathrooms and kitchens.

Figura 20: Percentage of responses and weighted average on the degree of importance of good daylighting per space.

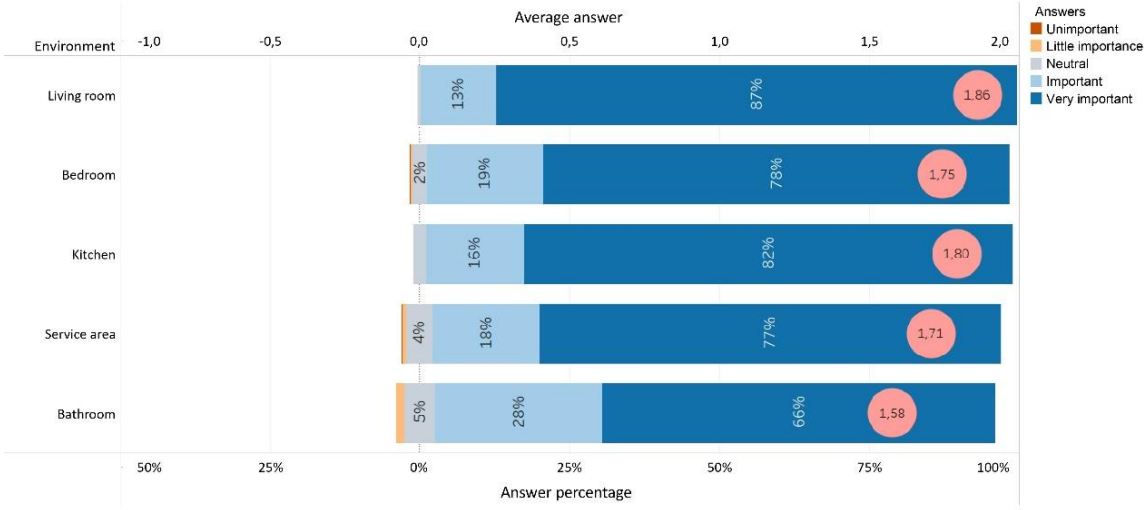


Figura 21: Percentage of responses and weighted average on the importance of the presence of sun per space.

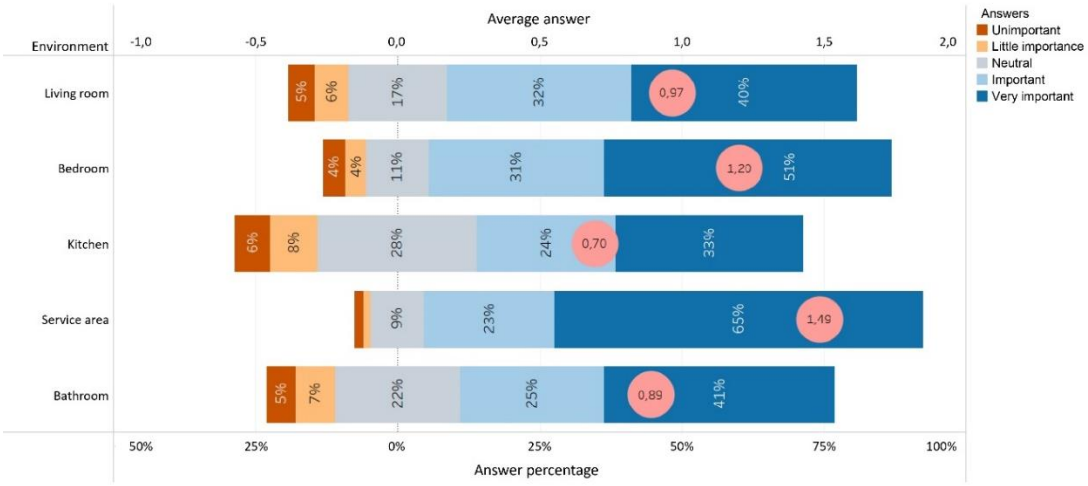
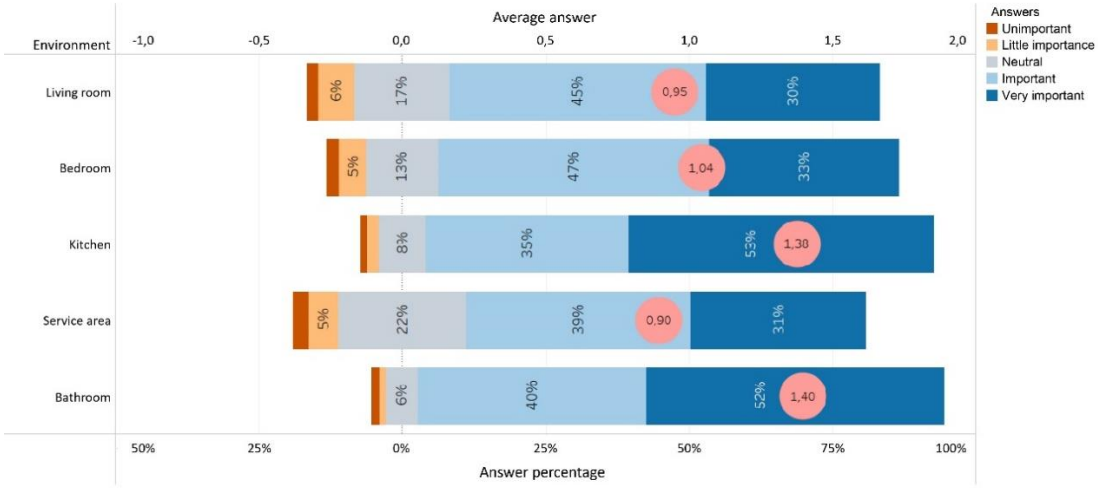


Figure 22: Percentage of responses and weighted average on the importance of good electric lighting per space.



Regarding the common use areas, it was found that most corridors outside the housing units do not have an opening to the exterior (54%), and when existent daylighting of these spaces is considered inadequate (mean -0.35), being the presence of good electric lighting considered as more important than good daylighting in these spaces. The respondents stated that 82% of the garages have an opening for daylighting, and that they consider the daylighting of these spaces in their buildings as "adequate" (average 0.10), with natural and electric lighting being considered equally important for this space.

It was asked how important it is to have good daylighting in indoor spaces when purchasing a property. Figure 23 shows that the living room, bedroom, and kitchen, in that order, are the most important spaces to be well daylit for the respondents, followed by the laundry area and the bathroom.

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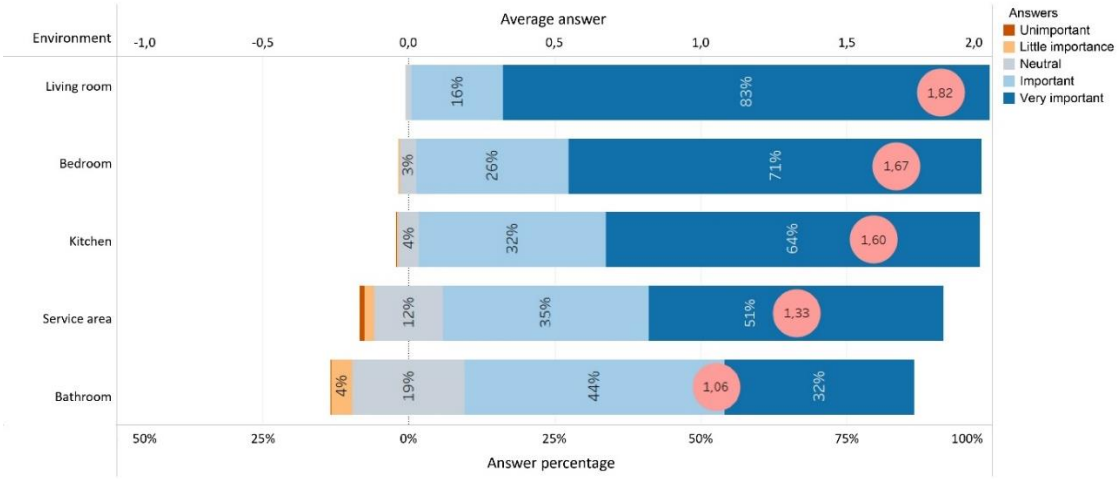
inadequate (mean -0.35), and the presence of good electric lighting is considered more important than good daylighting in these spaces. The respondents stated that 82% of the garages have an opening for daylighting, and that they consider the daylighting of these spaces in their buildings as "adequate" (average 0.10), with natural and electric lighting being considered equally important for this space.

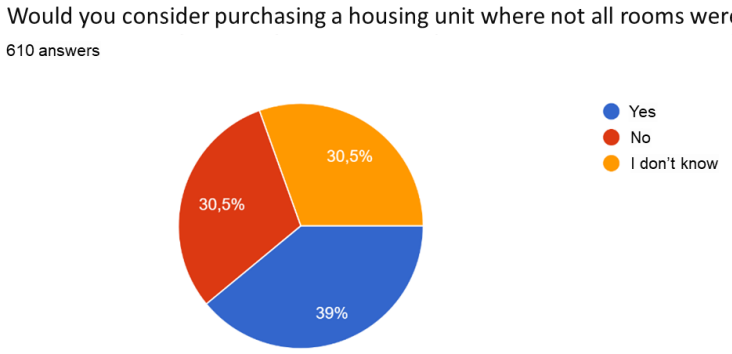
It was asked how important it is to have good daylighting in indoor spaces when purchasing a property. Figure 23 shows that the living room, bedroom, and kitchen, in that order, are the most important for the respondents, followed by the laundry area and the bathroom.

Figure 23: Percentage of responses and weighted average on the degree of importance of good natural lighting when purchasing a property by space.



Respondents were asked about the possibility of purchasing a housing unit in which not all rooms were well daylit. For this question, the answers were divided into "yes", "no" and "I don't know" proportionally, with slight higher indications of “yes” as shown in Figure 24.

Figure 24: Preference for all rooms to be well lit when purchasing a property.



Finally, when asked about the daylight perception in the residential space after the pandemic period, 44% of respondents stated that it has become more important and 54% of respondents declare that there has been no change in perception.

The questionnaire left room for the free manifestation of the respondents, in which situations that were not addressed in the questionnaire, such as different types of

openings from those existing in the questionnaire, and the presence of trees as elements that obstruct daylighting was also reported. Respondents complaints about their home daylighting were better explained, both for lack of privacy and excessive insolation, as well as for lack of daylighting in bathrooms inside the UHs or in spaces facing a daylighting pit. Observations were also made regarding the interrelationship of daylighting with natural ventilation and with issues related to the thermal performance of housing units, topics not addressed in the questions asked.

There were no complaints regarding the length of the questionnaire (82 questions could be considered extensive), and several compliments were received. It is believed that the care in asking short and objective questions, of multiple choice or in matrix format, helped to receive a significant number of answers. Finally, an observation caught our attention: *I had never thought about the daylighting in my apartment as a whole. Thank you for the reflections.*

4 Conclusion

This article aimed to shed light on the subjective preferences of users in relation to daylighting in residential spaces through the application of a questionnaire. A total of 542 valid responses were obtained, which were tabulated according to a Likert scale.

The evaluation of the answers to the questionnaire made it possible to verify the daylight perception by the users in their homes. In general, residences located in neighborhoods with high density had the worst weighted averages in the daylight quality evaluation when compared to residences located in regions with medium and no density. Regarding the typology, the apartments presented better results than the houses, and for the regions of high density, the latter have greater representativeness.

Regarding the openings, the predominant openings in the living room are windows, with a conventional sill and with a lower sill being the ones with the highest occurrence. In bedrooms, windows are also found to be the predominant opening type, with 50% presenting with sliding glass sheets, 32% presenting a sliding shutter and 10% presenting an integrated shutter. Of the opening models, it is worth noting that those with larger daylighting areas, such as windows with low sills and door-windows, showed better results regarding the daylight quality perception in the space. On the other hand, the presence of a balcony with a masonry sill was the type of opening with the worst results. Both in the bedrooms and living rooms, clear glass accounted for more than 80% of the sample, but it was not preferred by users. In the living room, even with little representation, mirrored glass/solar control was preferred by most users in the apartment typology.

Regarding the immediate surroundings in front of the openings of the living room and bedrooms, it was noted that the obstruction, both in height and proximity, as is the case of a boundary wall near the opening, impairs the perception of the daylight presence in the space. The absence of the surroundings in front of these openings contributes to obtaining better averages of daylight quality.

From the results, it is observed that the spaces that should receive greater attention from designers, to ensure a better daylight quality, are kitchens and bathrooms. These two spaces had a weighted average close to zero (referring to the daylighting adequacy). This is reinforced when the results on the usage of electric lighting during the day are correlated, with the kitchen and bathrooms being the spaces with the highest activation.

In addition, it is possible to note that, according to the research carried out, the use of indirect daylighting in the kitchen through the service area should be avoided, since it is the type of opening that presents a perception of lower daylighting quality in all situations analyzed. It was also noticed that American kitchens present better results when compared to closed kitchens, because there is the daylight contribution from another space. Parallel to this, during the pandemic, its time of use increased by almost 50%, and it should be noted that users characterized the kitchen as the second highest priority space for good daylighting, out seconded only by the living room.

From the results obtained by the questionnaire, it was possible to correlate the users' preferences about the typical elements and layout of residential buildings - such as types of glazing and openings, obstruction of the consolidated surroundings and access to daylight - with their perception of the daylight quality.

It is considered that the study helps in the determination of spaces that are important for the daylighting analysis, as well as helps in the evaluation of which spaces have had their daylighting impaired due to the high density or internal configuration of residential spaces and the user's perceptions should be taken into account in the positioning and direction of metrics established by Brazilian standards.

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