OCULUM ENSAIOS
REVISTA DE ARQUITETURA E URBANISMO

DOSSIER: AGEING, TERRITORY AND ENVIRONMENT

Editors
Alejandro Perez Duarte Fernandez e Patrícia Samora

Support
This research was funded by the CAPES PRINT Program Process number 88887.578505/2020-00.

Conflict of interest
There is no conflict of interest.

Received
May 14, 2024

Final Version
Sep. 30, 2024

Approved
Oct. 8, 2024

Protocol for safe housing environments to support aging in place

Protocolo para ambientes de moradia seguros como suporte ao aging in place

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Como citar este artigo/*How to cite this article*: Tissot, J. T.; Vergara, L. G. L. Protocol for safe living environments to support aging in place. *Oculum Ensaios*, v. 21, e2412774, 2024. https://doi.org/10.24220/2318-0919v21e2024a12774en.

Abstract

The projection for the year 2050 indicates that the number of people over 60 years old will increase to approximately 2 billion, placing Brazil in the 6th place in the ranking of countries with the largest older adults. Aging can lead to significant physical and cognitive changes over the course of life, highlighting the need for a new perspective on housing environments. The creation of lifelong adapted housing allows individuals to maintain independent living conditions in their own homes or chosen environments. In this context, this research aims to present a protocol for safe housing environments for older adults, with design strategies to support aging in place. Using a multimethod approach, the results indicated that the design of these environments should incorporate the principle of flexibility and prioritize the lifestyle of the users. Additionally, architectural design must consider the future needs of users. This way, changes can be made without major structural alterations to space. It is concluded that the concept of aging in place can contribute to the formulation of public policies aimed at creating safe housing for the older adults in Brazil.

Keywords: Architecture. Aging. Safe.

Resumo

A projeção para o ano de 2050 indica que o número de pessoas com mais de 60 anos aumentará para aproximadamente 2 bilhões, posicionando o Brasil em 6° lugar no ranking de países com maior população idosa. O envelhecimento pode acarretar significativas mudanças físicas e cognitivas ao longo da vida e com isso surge a necessidade de uma nova visão acerca dos ambientes de moradia. A criação de moradias adaptadas para a vida toda possibilita que as pessoas mantenham condições de vida independentes em suas próprias residências ou no ambiente que escolherem. Nesse sentido, esta pesquisa tem como objetivo apresentar um protocolo para ambientes seguros para a pessoa idosa, com estratégias projetuais que deem suporte ao aging in place. A partir de uma abordagem multimétodos, os resultados indicaram que o projeto desses ambientes deve considerar o princípio de flexibilidade e priorizar o estilo de vida dos usuários. Além disso, o projeto arquitetônico deve levar em conta as futuras necessidades dos usuários. Dessa forma, mudanças podem ser realizadas sem grandes alterações estruturais no espaço. Conclui-se que o conceito de aging in place pode contribuir para a formulação de políticas públicas voltadas à criação de moradias seguras de pessoas idosas no Brasil.

Palavras-chave: *Arquitetura. Envelhecimento. Segurança.*

Introduction

Population aging can bring about significant changes that influence physical and mental health, as well as interfere with functional performance and the affective and social relationships of older adults (Mendes; Côrte, 2009). There is a projection that by the year 2050 the number of people over 60 will increase to approximately 2 billion, and within this panorama Brazil will be the 6th country in the world in terms of the number of older adults (Romeiro *et al*., 2010). Public policies have been planned and implemented to ensure strategies for active and healthy aging among this population, but most of them refer to social security, welfare, health, education, work, and income (Braga *et al*., 2012), with little emphasis on aspects related to housing.

One of the biggest challenges faced by older adults is falls. This event is one of the main causes of morbidity and mortality and is also associated with restricted mobility, fractures, depression, functional incapacity (Menezes; Bachion, 2008), loss of independence and autonomy, institutionalization and a decline in quality of life, as well as generating socio-economic implications and a burden on the health system (Lopes; Dias, 2010).

Data from DATASUS (2021) shows that in Brazil, between 2008 and 2021, there were 357,078 hospitalizations due to falls. Because of their frequency, morbidity, and high cost to health services, falls should be seen as a public health problem (Shimada *et al*., 2010). In addition, the high prevalence of this type of accident, as well as its consequences for the health of older adults, shows the need to develop and implement effective strategies to tackle this situation (Alhambra-Borrás; Durá-Ferrandis; Ferrando-García, 2019).

It is known that many falls occur in the context of older adults' home. (Fletcher *et al*., 2009; Pereira *et al*., 2013; Santos *et al*., 2012; Soares *et al*., 2014; Sousa; Vieira; Branco, 2017; Yoo *et al*., 2019) Thus, the planning of the environment must take into account the relationship between the person and the place where they live, based on the understanding that the house expresses their identity, with significant and personal marks for the construction of their means of protection and well-being. Changes resulting from an aging population have led to a new view of care and housing, as well as prioritizing functional independence and autonomy.

Falls have multifactorial characteristics and are mostly the result of a complex interaction between different risk factors. The circumstances of falls in the home include, for example, going downstairs, bathing, transfers, and tripping during the balance phase of walking and moving (Oliveira *et al*., 2014).

The World Health Organization classifies the risk factors for falls into four dimensions (World Health Organization, 2007):

- Biological factors: age, gender, race, chronic illnesses and physical or cognitive decline;
- Behavioral factors: use of multiple medications, excessive alcohol intake, or lack of physical activity;
- Environmental factors: unsuitable home or neighborhood, such as inadequate design, slippery floors and stairs, loose carpets, insufficient lighting, and uneven sidewalks, among others;
- Socio-economic factors: income, schooling, access to adequate housing, community services and social interaction.

Although environmental risks are common in the homes of older adults with or without disabilities, there are still gaps and a need to understand which attributes of the environment are directly related to falls (Blaz *et al*., 2020; Leiva-Caro *et al*., 2015) and how these spaces can be made safer for older adults.

The environment in which older adults live should be thought of as a space that takes into account the personal expectations, cultural aspects, aesthetic standards, functionality, safety, and economic conditions of those who inhabit it. In this sense, designing an environment suitable for this audience implies observing all these aspects, without in any way impeding the social use of other individuals. Only in this way will we work to enable the interaction between the person, with all their characteristics, and the environment in which they live (Romeiro *et al*., 2010).

In this sense, *aging in place* has emerged (Wiles *et al*., 2012), which aims to enable users to maintain independent living circumstances in their own homes. A survey carried out in the United States found that 90% of people over 65 would like to remain in their homes for as long as possible and 80% believe that their current home is where they will live forever (Bauman *et al*., 2016). Having a suitable environment for the older adults helps them to carry out their activities of daily living independently and safely.

The home, as a care center, establishes the relationship between functional capacity, personnel and the physical home environment, known as the person-environment relationship, and involves issues of accessibility to housing and dependence on Activities of Daily Living (ADL) (Tomazzoni, 2011).

In terms of health assessment, Activities of Daily Living (ADL) are subdivided into:

- Basic Activities of Daily Living (BADL): involve activities related to self-care such as feeding, bathing, dressing, grooming, and mobilizing;
- Instrumental Activities of Daily Living (IADL): indicate the individual's ability to lead an independent life within the community in which they live and include the ability to prepare meals, go shopping, use transportation, look after the house, use the telephone, manage their own finances and take their medication;
- Activities of Daily Living Engagement (ADLE) (Ramadhani; Rogers, 2021): refers to socialization activities such as receiving friends and meeting people, having a distraction, or some entertainment.

The successful conduct of these activities depends on the physical space available. The lack of accessible environments contributes to increasing the difficulties in carrying out these activities (Ramadhani; Rogers, 2021).

When health declines, environmental limitations begin to conflict with individual capacities, which results in problems between the user and the environment, as well as negative health outcomes. These problems highlight the importance of environmental adaptations in order to minimize the risk, especially of falls, among older adults (Bhidayasiri *et al*., 2015).

The appropriate combination between the user and the physical environment generates a more adequate performance in relation to the activities of daily living of older adults, which is why it is important to understand their behavior and their spaces, especially in old age. The interaction between person and space describes how older adults adapt to environments to achieve this combination of competence and environment (Leiva-Caro *et al*., 2015).

Although there are many challenges imposed by the conditions of the built environment, interventions in the physical space are less common than adjustments between the user and their behavior towards the environment - which would not be ideal. There are opportunities for interventions in the built environment to help older adults successfully conduct their activities of daily living and thus age in their homes more safely and autonomously (Ramadhani; Rogers, 2021).

In this way, architectural and *design* solutions can guarantee older adults a safer living environment in the same space they are used to, and therefore enable them to live longer. For this, not only technological interventions are important, but also interventions related to physical space (Lee; Kim, 2020; Lien; Steggell; Iwarsson, 2015).

Adaptations to the environment are aimed at ease of use, safety, security, and the independence of its users. Modifications can include changes such as widening doors or adding a bathroom on the second floor, a ramp, and the installation of specialized equipment (Maggi *et al.*, 2018).

Housing plays a fundamental role in the aging process, so the space in which older adults live is recognized as a key player in this phenomenon. Thus, architecture, ergonomics, *design*, accessibility, and universal design are related disciplines that can be considered to aid a healthy aging process. Adapting housing to the needs of the older adults and respecting the changes inherent in physical and cognitive abilities is necessary so that ADLs can be carried out comfortably and safely, as well as promoting the independence and autonomy of these users (Hazin, 2012).

In this sense, this research presents the development of a protocol for safe living environments for older adults, with design strategies that support and encourage *aging in place*. To this end, an investigation was carried out in three stages - bibliographical research, survey, and protocol development - in order to understand how the physical environment and architectural attributes are related to reducing the risk of users carrying out their activities of daily living with independence, autonomy and, consequently, a better quality of life.

Protocol for Safe Environments for Older Adults

The development of a protocol for safe living environments aims to propose design guidelines for each living space - entrance door, living room, dining room, kitchen, bathroom, bedroom, office, laundry area, and garage - in order to minimize the risks that the physical environment during older adults' activities of daily living, considering the decline in functional and cognitive capacities.

The research was structured in three main stages: (1) bibliographic research through a systematic literature review, using the StARt tool - *State of the Art through Systematic Review* (Zamboni *et al.*, 2010), which made it possible to verify the current state of the art and understand the context and occurrence of falls among the older adults, as well as their consequences. A (2) data survey was also carried out at the University of Illinois at Urbana-Champaign (USA) in order to obtain information on how older adults carry out their activities of daily living (BADL, IADL, ADLE) in a living environment and, on the basis of this survey, to find solutions for these safety-related spaces. The survey was carried out with researchers in the fields

of architecture, design, and aging using participatory methods such as *walkthroughs* and focus groups.

Finally, (3) protocol development was the stage in which corrective and preventive ergonomic actions were defined for the planning of living environments. A content analysis (Bardin, 2011) of the data obtained in stages 1 and 2 revealed the most recurrent architectural attributes through a frequency analysis. Next, a questionnaire was developed with the aim of verifying the degree of importance of these attributes from the previous stage in relation to safety in the living environment of older adults. The questionnaire was applied *online* to architecture, engineering, and design professionals in Brazil and was approved by the UFSC Research Ethics Committee (CAAE 57822022.3.0000.0121) under opinion no. 5.425.909.

The definition of design guidelines is also divided into three levels of safety: minimum, medium, and maximum. The levels were defined based on the result obtained by applying the GUT Matrix (severity X urgency X trend), as shown in Table 1 below:

Chart 1 - GUT Matrix.

Gravity	Urgency	Trends
Financial factor	Time factor	Trend factor
Impact that a given situation will have on those involved	Deadline for a given situation to start causing negative impacts	Probability of a given problem getting worse over time
	Score	
1 Not serious	1 Can wait	1 Will not change
2 Slightly serious	2 Not very urgent	2 It will get worse in the long term
3 Grave	3 Urgent, deserves attention in the short term	3 It will get worse in the medium term
4 Very serious	4 Very urgent	4 It will get worse in the short term
5 Extremely serious	5 Needs immediate action	5 It will get worse quickly

Source: adapted by the authors from Cesar (2013).

Severity is defined as the impact of a problem or situation on those involved, be they people or processes. Urgency relates to the time or deadline available to solve this problem. If something is very urgent, the deadline for resolving it should be shorter. The trend means that the problem is likely to get worse over time if nothing is done. Each factor is given a score from 1 to 5, where 1 is the least serious and 5 is the most serious (Cesar, 2013).

Priority was defined according to the following scoring scale: 0 to 24 points, priority level 3 or low; 25 to 59 points, priority level 2 or medium; and 60 to 125 points, priority level 1, or high. This means that if an attribute has a high weight, for example, 125, it should be prioritized as number one or high. The value of 125 is obtained by multiplying the severity, urgency, and trend factors. This result indicates that the item is an extremely serious risk that requires immediate action and that, if not implemented, the risk could worsen rapidly. In this sense, priority 1 is associated with minimum safety, since it is understood that if the item is a serious risk, it should be considered basic to guarantee the safety of users.

The scoring of the GUT Matrix took into account the recurrence of the attributes in the literature (Stage 1), in the Focus Group (Stage 2), and also in the results of the application of the Questionnaires (Stage 3).

In order to define the guidelines, a classification was also developed for the attributes of the environment, as shown in Table 2 below:

Chart 2 - Classification for design guidelines.

Simbology	Classification	Definition	Example
	Structural changes	Renovations and new constructions They require a greater investment of money and time.	Changing the size of rooms by eliminating walls, opening or closing windows, building ramps, *etc.*
	Regulations	Equipment and elements of the home that comply with the regulations.	Door size, corridor width, *etc.* Compliance with NBR 9050.
	Equipment	Equipment to help use the environment and carry out activities of daily living BADL, IADL, ADLE.	Support bars and handrails, etc. Adequate reach, accessible switches, electrical appliances, etc. Artificial lighting (general or task) and emergency lighting.
	Assistive Technology	Installation of assistive technologies.	Use of voice control devices or even automation of furniture, etc., as well as presence, gas, or smoke sensors.
	Building materials	Changing or replacing floor coverings, walls, countertops, etc., or even implementing the use of colors and contrasts.	Surfaces, thresholds, or even worktops etc.
	Furniture	Replacement of fixed or loose furniture.	Tables, chairs, armchairs, sofas, etc.
	Maintenance	Minimal actions and repairs were carried out manually.	Removing carpets, exposed wires, loose objects or even cleaning the room, etc.

Source: Tissot (2022).

The first column shows the symbology, the second column classifies the design guidelines, the third column defines each type of guideline and the last column gives examples related to the classifications presented. In addition to the classification according to the table above, the protocol with design guidelines was segmented into safety levels to make it easier to visualize and define the ergonomic actions to be implemented in the environments.

Results

In this article, due to the limited number of pages, we will present a snippet of the results. Table 3 summarizes the protocol for defining the design guidelines for the living spaces.

In the first column are listed the classifications to which each guideline belongs, and in the second column, the priority level of each guideline (according to the result of the GUT Matrix). The third column summarizes the guidelines for safe living environments. Columns four, five and six show the scores from the GUT matrix, and column seven is the result of multiplying these points. The higher the score, the higher the priority of the elements. Column 8 shows the living environments and, as this table is a summary, the environments in which each guideline should be implemented are scored.

Chart 3 - Definition of design guidelines based on the GUT Matrix.

Classification	Priority	Guidelines	Gravity	Urgency	Trends	Score	Entrance door	Living and dining	Kitchen	Bedroom	Office	Bathroom	Service area	Garage
Equipment	1	Support bars / Handrails.	5	5	5	125	◆	◆	◆	◆	◆	◆	◆	◆
Materials Constructive		Non-slip floor covering.	5	4	5	100	◆	◆	◆	◆	◆	◆	◆	◆
Maintenance		Loose carpets (avoid).	5	4	5	100		◆	◆	◆	◆	◆	◆	
Structural		Ramps - NBR 9050.	5	5	4	100	◆							
Assistive Technology		Smoke sensor.	5	5	4	100		◆	◆	◆	◆	◆	◆	◆
Equipment	2	Exhaust ventilation.	3	4	3	36			◆			◆	◆	◆
Equipment		Bench inside the shower.	3	4	3	36						◆		
Equipment		Glass box (avoid).	3	4	3	36						◆		
Furniture		Light furniture.	2	4	4	32		◆	◆	◆	◆			
Furniture		Furniture close to the wall.	4	4	2	32		◆	◆	◆	◆		◆	
Maintenance	3	Emergency contact.	2	3	4	24			◆	◆		◆		
Equipment		Emergency alarm.	3	4	2	24			◆	◆		◆		◆
Constructive Materials		Easy-care coating.	3	3	2	18	◆		◆			◆	◆	◆
Furniture		Variety of furniture.	3	3	2	18		◆		◆				
Equipment		Anti-fog mirror.	2	3	3	18				◆	◆			
Equipment		Electric towel rails.	2	1	1	2						◆		

Source: Tissot (2022).

Below is a selection of some of the design guidelines, in this case for the bathroom, which deserves attention due to the complexity of the activities carried out. In addition, because this environment is often small, the limited space has a direct influence on tasks, movement and handling.

Basic activities of daily living are carried out in the bathroom, such as bathing, dressing, *etc.* Some references also show that this is an environment where many falls occur among older adults, so attention should be paid to recommendations that help prevent and reduce this type of accident. Table 4 shows the design guidelines for this space, associated with the safety levels.

The criteria for achieving the minimum level of safety in the bathroom include the installation of drains both inside and outside the shower so that, in the event of a leak, the water can be drained away. Avoiding unevenness is another important point. The differences between wet and dry areas should be bridged with a floor layout that indicates the fall to the drains. You should also pay attention to the regulations in terms of respecting the minimum dimensions (Associação Brasileira de Normas Técnicas, 2020) in the case of wheelchair users (turning area). Artificial lighting is important and essential for carrying out tasks. It is also important that there is enough light both in the room in general and in the shower area. Emergency lighting is necessary to prevent accidents in the event of a power failure. Another extremely important item for the bathroom is the installation

of grab rails, especially for access to and from the shower and toilet. For furniture, we recommend using drawers and respecting the users' reach. With regard to the shower, another recommendation would be for the position of the mixers for opening the shower to be close to the entrance to the shower to prevent the person from getting wet when opening it and, in the case of very hot water, to avoid accidents. The height of the toilet must also respect the physical restrictions and abilities of the users. Items such as smoke, gas, and humidity sensors help with safety. In addition, as in other environments, color contrast helps to identify barriers. As far as floor coverings are concerned, they should always be slip-resistant. Another item to avoid is loose rugs, as their use is associated with falls. As the bathroom is a place where this item is often necessary, the ideal solution is to try to embed it on the floor or use adhesives to fix the rugs on the floor.

Chart 4 - Bathroom guidelines based on the security level.

Location:	Bathroom		
Activities of Daily Living:	**Basic** BADL X	**Instrumental** IADL	**Engagement** ADLE
Minimum safety (MIN) *GUT: 60 to 125 points*	**Medium Security (MED)** *(MIN+MED)* *GUT: 25 to 59 points*		**Maximum security (MAX)** *(MIN+MED+MAX)* *GUT: 0 to 24 points*
- Drain - Unevenness (avoid)	- Location of the environment - Natural lighting		- Dimension
- Standard (NBR 9050) for dimensioning			
- Emergency lighting - Support bars - Artificial lighting (general or task lighting) - Use of drawers - Suitability range	- Box seats - Glass box (avoid) - Outward opening door - Handle (lever type) - Handle model - Exhaust ventilation		- Electric towel rails - Anti-fog mirror - Electrical protection sockets - Lock that opens the door from both sides - Flexible shower
- Smoke sensor - Gas sensor - Humidity sensor	- Intercom/communicator		- Door opening device - Emergency alarm - Emergency contact - Water thermostat
- Color contrast - Non-slip floor covering	- Smaller coatings		- Easy-care coating - Water-resistant materials
- Loose carpets (avoid)	- Built-in wiring		

Source: Tissot (2022).

With regard to the criteria for the medium safety level, in addition to the items listed above, we have to used smaller tiles, especially in the shower area, so that there is more grouting and, therefore, more grip for the user. Issues such as air exhaust and natural lighting from large openings are aspects that contribute to safety, due to the humidity of natural ventilation. Another point to discuss is the location of the bathroom in relation to the other rooms in the house. In most homes, this area is next to the bedrooms, but it turns out that it isn't always. In this way, it should be noted that the rooms in the house should be close to each other due to their complementary uses. Therefore, it is recommended that the bathroom be close to the bedroom. A fixed or retractable bench should be installed above the shower to older adults people who find it difficult to stand for

long periods of time. That way you don't have to move a shower chair around. Another strategy is to avoid glass enclosures or enclosures with curtains if the size of the room allows it. As a replacement, the ideal would be to build a masonry wall with a height of approximately 1.20 meters and above this wall a fixed glass to avoid water splashing into the room and to consider, according to the user, an access width that is barrier-free for access to the shower. The door to this room is recommended to open outwards, provided there is enough space outside for it to open fully. If this is not possible, the solution is sliding doors or a door that opens inwards, but with the addition of opening systems. Lever handles are recommended, as are handles for furniture. In terms of assistive technologies, an intercom/voice communication system in the bathroom and an emergency alarm are installed. Because of the humidity, the wiring in the bathroom must be embedded in the wall.

For the maximum safety level, there are issues related to the small size of this environment, both in the case of environmental adaptations and new projects. Therefore, it would be important to consider the size as a criterion in order to check whether it is adequate or appropriate in terms of the equipment and activities that will be carried out in this space. The layout and the position of equipment, such as the sink, toilet, and shower, must be positioned to the detriment of the tasks. It is also advisable to install electric towel rails to make it easier to dry towels, an anti-fog mirror, and electrical protection for sockets to prevent accidents in the event of excess humidity. In addition to the possibility of opening the door from outside the room, the installation of locks that make it possible to open from both sides, as well as assistive technologies that make it possible to open the door, are recommended. Alarm and emergency contact in a visible place so that in the event of an accident, measures can be requested quickly. The thermostat is another piece of equipment that can be placed on the sink faucet and in the shower so that the water temperature can be viewed. A flexible shower head should also be installed inside the shower to aid in bathing. Finally, the use of water-resistant materials also helps to prevent the furniture from deteriorating and possible accidents, and they are easy to maintain.

Final Considerations

Research in various areas of knowledge seeks to identify functional, biological and behavioral limitations attributed to older adults, and when it comes to this public in particular, the subject becomes even more relevant due to projections regarding the increase in this population in Brazil and worldwide.

There is still little research in the field of architecture and urbanism on this subject, but it should be noted that among the various determinants of active and healthy ageing, the environment is one of them. In addition to the discussion about public policies aimed at social, economic and health issues, the space in which the elderly person lives is extremely important in this process.

The World Health Organization (2017) considers that poorly lit, poorly planned environments with architectural barriers are the most common causes of falls in older people. Data from Brazil's Unified Health System shows that these accidents are one of the main reasons why older adults go to hospital and are also one of the main causes of death. In addition to the issue of the fall itself, another aspect that should be mentioned is its consequence, which involves restricting activities of daily living due to the fear of falling again, as well as the loss of independence and autonomy.

For safe and accessible environments to be possible, a greater understanding is needed of the risk factors present in these spaces and the factors that directly influence the performance

of daily living activities. Understanding their difficulties, abilities, and disabilities is the first step towards designing environments suitable for this population. In order for anyone to live an independent and autonomous life, the physical space needs to be adequate to meet the demands so that basic, instrumental, and engagement activities can be developed in order to guarantee minimum conditions for active and healthy aging. A suitable environment influences the degree of user satisfaction, which consequently influences the level and perception of well-being. Providing conditions for activities to take place safely, with minimized risks, means providing conditions for active and healthy aging to take place.

The guidelines drawn up based on the protocol make a significant contribution to strengthening the concept of *aging in place in* Brazil and also as a tool for implementing public policies through booklets and lectures in partnership with government bodies in Brazilian cities.

In addition, architectural professionals who design environments must have the premise of creating safe environments no matter the skill level or age of the user, as aging is a process. The flexibility of living spaces must be taken into account, and the lifestyle of users must be prioritized. Thus, changes to certain environments and functions can be made as new demands arise without major modifications.

The guidelines derived from the protocol can also be used by the general public to adapt the environment in order to make it more suitable and safe for use, as it is not necessary to wait for an accident to occur or for a risk to be present in the environment before adapting. In this way, it is hoped that people will be able to age in their homes with a better quality of life, independence and autonomy.

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Collaborators

J. T. Tissot e L. G. L. Vergara contributed with: Conceptualization and Writing - proofreading and editing. J. T. Tissot also contributed: Data curation, Formal analysis, Acquisition of funding, Research, Methodology and Writing - original draft. L. G. L. Vergara also contributed with: Supervision, Validation and Visualization.